SCHOOL SCIENCE AND MATHEMATICS

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BIOGRAPHY AND HISTORY IN SCIENCE TEACHING

BY C. HARRISON DWIGHT

University of Cincinnati, Cincinnati, Ohio

Count Rumford (1753–1814). This man was as varied in his interests as he was in his places of abode. Born in Massachusetts, he taught school in New Hampshire, lived in London, revisited the United States, resided for quite a while in Munich, and died in Auteuil, near Paris. At the age of fourteen he was familiar with draughting, physics, chemistry, anatomy, and surgery. Within ten years he knew, from first-hand experiences, the science of military defense and offense. He made a very fine study of political and social reforms, such as helping soldiers to become thrifty, eliminating paupers from the streets, instituting public kitchens, and reducing interest rates. He inaugurated the use of new recipes in cooking, emphasizing the value of the Irish potato, Indian corn, and Italian macaroni. He designed more efficient fireplaces and chimneys, invented a new type of cook stove, and showed how economy in fuels could be effected. He suggested improvement in the efficiency of clothing as a means of keeping the body warm, experimented with light, color, gunpowder, novel types of firearms, and horticulture. He tried to improve the breed of horses and of horned cattle. As a physical scientist Rumford endowed medals for the Royal Society of London, and the American Academy of Arts and Sciences. He founded the Royal Institution of Great Britain, celebrated later as the laboratory of Faraday. He is known in physics chiefly as the inventor of the Rumford photometer, and the experimenter who proved that heat generated by friction

comes from the *work done* rather than from some mysterious "caloric" squeezed out of the surfaces. In 1783, after his second return to England, he was knighted by George III. It was not until 1791 that he was called "Count Rumford." In that year, as a reward for his outstanding investigations in water and heat, he received the title Count of the Holy Roman Empire. His real name was Benjamin Thompson. In twenty years he had risen from the position of teacher in a rural school in the American colonies, to be one of the foremost scientists of the world. And yet, as Count Rumford the scientist, he probably never forgot the satisfaction of having been, as plain Mr. Thompson, an instructor of youth in the promising New World. Indeed, he deliberately chose the name "Rumford" because it was in the little New Hampshire village of Rumford that he first tried his wings in the flight to fame.

ASSOCIATION NEWS

President W. R. Teeters has made a wise selection in appointing Miss Ada Weckel of Oak Park and River Forest Township High School to take the place of Mr. G. T. Franklin, deceased, as chairman of the Journal Committee and Mr. Theodore D. Kelsey of the Grover Cleveland High School, St. Louis, to take the place of Mr. Franklin as a Director of the Association.

Miss Weckel, who has a Master of Science degree and is a member of Sigma Xi, has been an active member of the Association for over twenty-five years. Miss Weckel served for many years as chairman of the Membership Committee, was elected President of the Association for the year 1929, and since that time has served on the Journal Committee. She has always contributed freely of her time in whatever capacity she has served the Association and her opinions have always been highly valued.

Professionally, Miss Weckel was one of the pioneers in the establishment of general science in the high schools of this country. The course was first introduced in Springfield, Massachusetts, and a year or two later in the Oak Part and River Forest Township High School. Miss Weckel is at present head of the biology department and dean of freshman girls in Oak Park

Mr. Kelsey has a Master of Science degree and is a member of Phi Beta Kappa and of the American Chemical Society. He has been an active member of the Association for many years and in 1924–25 served as Vice-President. He was contributing editor of the *Journal of Chemical Education* for eight years and was Secretary and Chairman of the Department of Science of the Missouri State Teachers Association.

Mr. Kelsey has taught chemistry in St. Louis High Schools since 1907. His long experience in the field of science teaching will make him a valued member of the Board of Directors of the Association.

HAROLD H. METCALF
Secretary and Treasurer

TELESCOPE MAKING IN THE WEST ALLIS HIGH SCHOOL

By Harold R. Stamm
West Allis High School, West Allis, Wisconsin

"Make a Telescope!" seems to be a favorite phrase in the "A" Physics course at the West Allis High School. The making of a four inch telescope was introduced as a project to create an interest in the study of the textbook chapters dealing with light and optics.

Our two great problems were: first, to create an interest in the projects; second, to bring the price of the instrument within the reach of every student.

Our first problem was solved by displaying in the classroom a model of a telescope and slides of heavenly bodies as might be seen with the instrument.

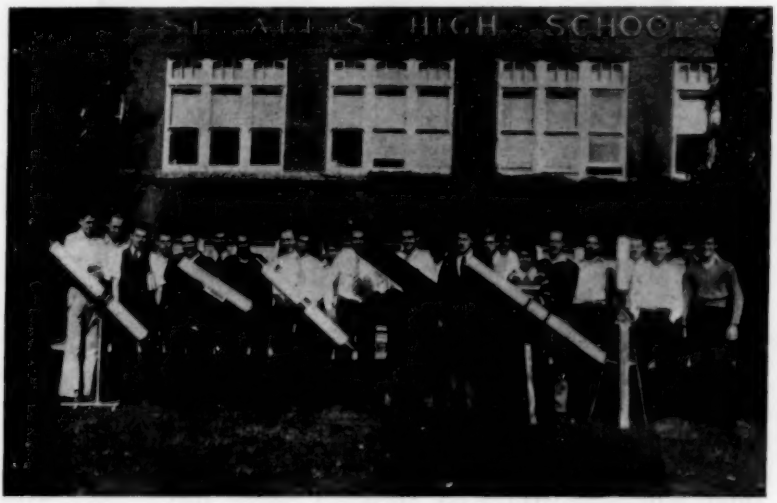


Fig. 1. A typical observing class.

Our second problem was overcome, after a bit of research work on price lists and materials by being able to make these telescopes for a minimum cost of one dollar and twenty-five cents ($1.25), without any enhancing or infringing on the accuracy and efficiency of the scope.

This instrument is not a playtoy. Newspaper headlines may be read at one half mile distance, and stars of the twelfth magnitude have easily been seen by the eye of a trained observer.

Our project was started by two boys, John Luczka and Edward Legel, when I gave them four glass casters, which heretofor had been used as paper weights and were admirably suitable to be ground into mirrors. (The mirror is the heart of the telescope.)

These boys proceeded to pitch the tool on a board, and a handle on a mirror and grind the casters in the classroom, one full period being spent on this work, with each student in the class taking his or her turn in grinding. When the students found that this task, so seemingly difficult, was comparatively easy,

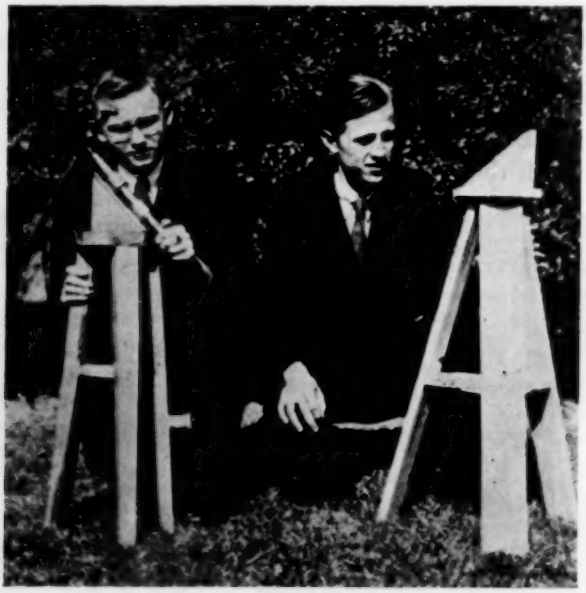


FIG. 2. Typical tripods.

they were eager to make their own telescopes. Specifically in three semesters over sixty students joined this project with more than twenty scopes now in use.

With such interest in evidence, it was apparent that large quantities of materials would be needed to complete the work. Consequently large orders were placed for the needed grades of carborundum in pound lots, pure pine pitch was purchased in ten pound lots. We scouted around for rouge to do the polishing and ended up with a ninety pound barrel of it.

We were then ready to begin production on a large scale, small packages were made up of materials, enough to complete a

mirror and sold for twenty-five cents. Some of this work was done in the laboratory and much of it at home in spare time.

FIG. 3. Preparation of the disk for grinding.

The question arose, "What do I need to get started?" First two glass casters four inches in diameter, two pieces of one-fourth (1/4″) inch board, two and three-fourths inches (2 3/4″) diameter. One of which is nailed to the center of an eight by eight (8″×8″) board (a size that can be easily fastened to the top of a barrel. Melted pine pitch is poured in the caster

FIG. 4. Miss Catherine Corak and her scope.

and the circular disk on the board is placed inside the caster. When the pitch is cool the board is turned over and the tool is ready for use. For ease of handling the mirror a handle is pitched on it by using the second disk of wood and nailing a common wood thread spool to it and pitching it to the mirror.

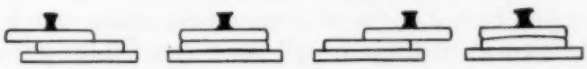


FIG. 5. Diagram of strokes and movements for grinding.

To grind the mirror it is advisable to use a barrel as a work bench, because by circling the barrel one of the three necessary motions of mirror grinding is accomplished. The mirror now

has a pinch of carborundum No. 80 and a drop of water placed between it and the tool and then the mirror is moved back and forth over the tool overlapping about one third of the mirror. With each stroke the mirror is also rotated in the hands one-fourth inch. After about six hours of this work a test for focal length is made. The mirror is made wet, and a lighted candle is placed in front of it and is slowly withdrawn until the candle inverts its image. This point is the radius of curvature, and one-half of it is the focal length. About the best focal length for a four inch (4′) mirror is forty-eight inches, giving a 12 to 1 ratio of aperture to focal length (F. 12). When this focal length is

FIG. 6. Telescope of scrap auto parts by Joe Loepfe.

reached, then a finer grade of carborundum is used to begin the work of fine grinding, in preparation for polishing. In the rough grinding you have a curve with mountain peaks, which must be ground down until they are all gone and finally polished out with rouge. The depth of the center of the mirror is twenty-two thousandths of an inch. This is very little; some of the boys have made mistakes and now dad has a new ash tray.

In order to know when to change to the next grade of abrasive (we used 80, 220, 300 and 600 carborundum), a microscopic examination of the ground glass surface was made and micro-

photographs were taken, these were projected on the screen to show a comparison of the surfaces with various stages of grinding. With 80 carborundum, the surface of the glass looked as though it had been gouged out by a steam shovel. The more

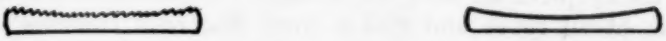


FIG. 7. Rough ground and polished disks.

work that is done with the 600 carborundum, the better (at least three hours); the polishing with rouge is thereby made easier. The work of polishing and figuring is done on a pitch-

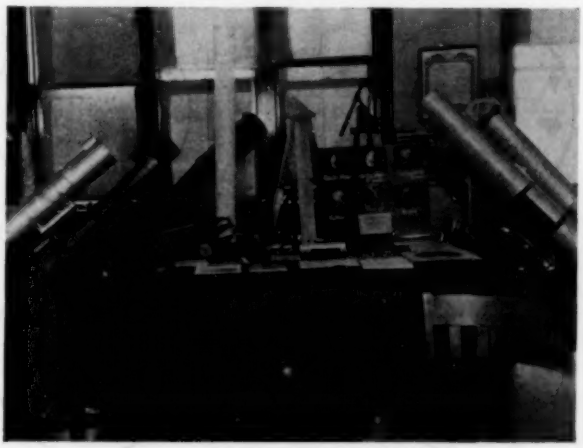


FIG. 8. Each semester we exhibit "Telescope Making" in our library.

lap. Pitch, tempered with beeswax, is poured over the tool. The mirror, fully rouged, edges and all, is pressed on and worked over the pitch, so as to form a surface coincident with the mirror and softer than glass, so that the particles of rouge may imbed themselves in the lap, forming thousands of cutting surfaces for polishing the glass surface.

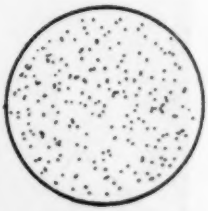
By using the Foucalt knife edge test, the mirrors were figured to a fine degree of parabolic perfection.

These mirrors are then ready to be silvered, which is done by the Brashear process, costing seventy-five cents. This may be found in a chemical handbook. Some were sent to Chicago and aluminized. These mirrors were mounted in tin cells made from coffee cans and the like, which were admirably and readily

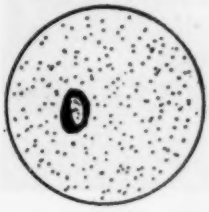
adjustable for the purpose. A three point suspension is used on the cell because of ease of alignment of the optical axis. By sighting the scope on an electric light bulb it is easy to center the image on the flat by using the 3 point suspension screws. For the eyepiece we have had a number of combinations, using lenses of all types and makes from discarded cameras, field glasses, binoculars, etc. fitting these together having a focal length of a centimeter and a half, or dime store magnifying glasses were secured and mounted in a tube to fit the eyepiece and were also found to be very satisfactory.

Now having the optical part of the scope complete, let us turn to the mounting (Fig. 2).

a. No. 80 Carborundum.



b. No. 400 Groundglass.



c. A pit in No. 400.

d. Half ground and half polished glass.

FIG. 9. Steps in grinding and polishing.

It has been of great interest to watch the construction of these bases, because each one is different showing the individual differences and the ingenuity of each student, and yet having the same Newtonian mounting principles. These mounts have been made from odds and ends found about the house; and parts from auto scrap heaps, where the front tie rods and bearings, half a rear axle housing, and a truck brake drum make up the mounting. In another case an old wooden frame bed spring was sawed up to form the legs for the telescope. Coffee cans filled with cement or lead were painted and used as counterbalances. The tube is made of five inch rain spouting 50 inches long. With a mirror 48 inches in focal length, the spider holding the flat or prism steady, is mounted six inches from the end of the tube. It

may be a three or four point suspension of one-eighth inch rods to hold the prism steady. The holder for the eyepiece called the rack and pinion is made to have about a four inch focusing movement, in and out from the flat.

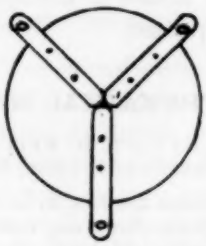


FIG. 10. 3-point cell suspension.

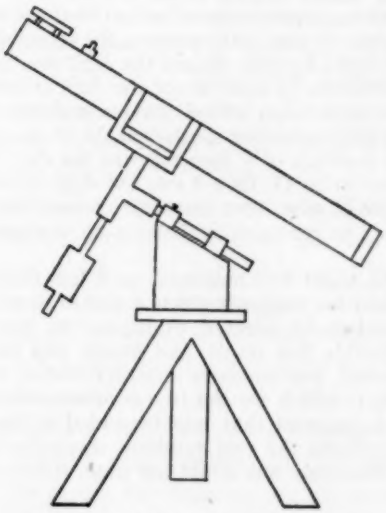


FIG. 11. A telescope mounting.

In the mounting, we must have a polar axis set true north and at an angle equal to your degree of latitude on the earth's surface. At right angles to the polar axis is the declination axis, on the end of which is mounted the tube. With this arrangement we may reach all parts of the heavens for observation. These scopes are portable and can be used at school, at the club, at church, lake, and home.

More unique, and original telescopes are being brought in each week, and interest has greatly increased in the study of the heavens, almanacs, maps, star guides, charts and time

tables, which formerly held only dust, are now eagerly thumbed for knowledge of the happenings in the heavens.

These telescopes are now being used for photographic work, variable star and meteor observation and sunspot and weather correlation. They will afford a lifetime of enjoyment when school days have long passed.

MATHEMATICAL MAGIC

By CECIL B. REED
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The fact that three numbers are free to be selected at random makes this trick rather effective. Write down any number you please. Either add or subtract any other number. Multiply the result by nine. Multiply this product by any number. Cross out any single figure of the answer. Add the remaining figures (digits) of the answer and state the sum. This trick, like many others, depends upon the fact that the remainder obtained by dividing a number by nine is the same as the remainder found by dividing the sum of the digits by nine. Before the digit was crossed out, the sum of the digits was divisible by nine; hence the digit crossed out must be one which when added to the sum stated, gives a multiple of nine. For example, if the sum of the remaining digits was 21, it is evident that 6 must be added to get a multiple of 9, hence 6 was the digit crossed out. If the sum stated happens to be 43, then 2 was the digit crossed out. If the sum is an exact multiple of nine, then the digit crossed out was either 0 or 9. The ambiguity may be removed by instructing to cross out any figure except a zero.

Ask some one to select two numbers, each less than ten. This may be done very effectively by suggesting that a pair of dice be thrown. Ask that either of these numbers be selected, multiplied by five, then six added to the result. Now double this result, and finally add the other number. If the sum is now stated, you mentally subtract twelve, and you will have a number of two digits which are the two numbers selected. If it is desired to repeat the trick, instruct that four be added at the second operation, instead of six. To obtain the two numbers, mentally subtract eight from the final result. Obviously one could use nine, subtracting eighteen, and so on indefinitely.

PINK-HEARTED CABBAGE GROWN FROM IMPORTED STOCK

A pink-hearted type of cabbage has been grown from stock imported from Turketan, at the experiment station of the U. S. Department of Agriculture, at Beltsville, Ma., Dr. Roy Magruder reports in the current issue of *Science*.

The heads are green outside. As the leaves are stripped off, the inner one are first the usual cabbage-white or cream color. Then, varying from a half-inch to three inches in diameter, there is an inner heart around the terminal bud, of pale pink or magenta color.

Dr. Magruder is sending the seed stock of this new cabbage type to Dr. C. H. Myers of Cornell University, who will continue the breeding experiments.

THE PREPARATION OF TEACHERS OF MATHEMATICS FOR JUNIOR AND SENIOR HIGH SCHOOLS

By William B. Aspinwall

President State Teachers College, Worcester, Massachusetts

There was a time, which is still within the memory of some of us, when it was assumed that an adequate knowledge of subject-matter and the confidence that came with the acquisition of a college degree were all that were needed to teach successfully in the high school. There was an opinion accepted more or less generally, which approximated the assertion made by a recent writer that "if an individual had brains enough to 'get through' college, he had intelligence enough to teach." But during the last quarter-century or a bit more, changes have taken place which have definitely affected the high school situation. We at the State Teachers College at Worcester have felt that our observation and experience justify the belief that there has been a strong and clearly discernible educational movement in the direction of greater faith in the efficacy of professional preparation of teachers for the secondary school. The traditional curriculum of the secondary school does not hold the dominant place that it once held. The high school is still the people's college and must provide for the majority of its students their final cultural preparation for life. For most high school students, therefore, preparation for college entrance can not be accepted as the chief objective of high school education. Furthermore, the study of psychology and of the meaning and processes of education has changed the traditional conception of what is needed properly to equip the teacher for his work. Mastery of a subject is still essential, but it does not carry with it the presumption of skill to teach it. Professional training for teaching is seen as no more illogical than the vocational preparation of those who seek to enter other fields of work. The establishment of departments of education in the liberal arts colleges bears evidence of this belief, as does the fact that there is an increasing number of teachers colleges that are undertaking the preparation of high school teachers. We are persuaded, therefore, that it is now almost universally believed that better high school teaching can be done if adequate professional education and training are required to supplement the mastery of subject matter.

Acting, therefore, upon these beliefs, we entered upon the task of preparing teachers for secondary schools twelve years ago. We organized and developed courses in six different fields,* one of which is mathematics, and we have been striving during these years to make the preparation in this field adequate to the needs of high school teachers. In determining the character and extent of the preparation needed for this purpose, we were guided by the opinions and standards of secondary school teachers themselves. We were not called upon to consider the requirements for certification of teachers, since Massachusetts does not have any state law requiring certification. We were not influenced by the requirements of any accrediting association, but we did base our judgment on a study of the deliberations of the secondary school teachers themselves. We did this not only in the case of teachers of mathematics but in the case of the teachers in other fields too, and as a result of that study we set up the minimum standard for a major study in any field at not less than 24 semester-hours of work, taken through the four years, with student-teaching additional. For the preparation for teaching mathematics, we have required 26 semester-hours of study in mathematics, and in addition have prescribed an introductory course in science; an introductory course in economics and adequate cultural training outside of the field of mathematics and the above related fields. This cultural work includes definite courses in English language and literature, American and European history, sociology, education and fine arts. Admission to the courses in mathematics is conditioned upon the satisfactory completion of the usual three years of high school study of mathematics, unless by reason of special conditions, the instructor is satisfied with a slightly different preparation, or is convinced that a student's preparation is such that he can profit by major work in this field. It is gratifying to note, however, that only rarely has any student entered this field of preparation with less than the usual high school courses in mathematics. Those who are ambitious to teach mathematics have usually made up their minds to do it while still students in the high school and have, therefore, taken in the high school all courses which will contribute to their preparation for teaching. Furthermore, it has been our observation that usually those who have liked mathematics sufficiently to take it throughout the high school course and then to continue its study through

* Latin, French, English, History and Social Studies, Geography and Mathematics.

four years of college have been students of high standing and ambitious to attain excellence in scholarship.

Although in the four years of college work, a student of mathematics is required to take courses of far broader scope of subject-matter and much more advanced in character and difficulty than those which he will be required to teach in the high school, nevertheless we have believed that four full years of the study of mathematics should be required, not only for the sake of the scholarship and training involved, but because that amount of subject-matter preparation was, we found, the accepted standard or possibly the ideal, of some groups of secondary school teachers.

To provide, therefore, for these students of mathematics who are preparing to become teachers of mathematics in Junior and Senior High Schools, a program of college courses of study covering four years is offered. This program comprehends: (1) courses in advanced subject-matter, taken through the four years; (2) acquaintance with the history and philosophy of mathematics; (3) review of the mathematics of the secondary school; (4) study of the teaching of mathematics; (5) actual student-teaching of mathematics under supervision; (6) assembly exercises based upon studies in mathematics. In this paper I will briefly outline the work done in these different lines.

1. Courses in Mathematics

Five courses, aggregating 26 semester-hours of credit, are required in this major study; in the first year, college algebra and solid geometry; in the second year, plane trigonometry and analytical geometry, together with a professional course in mathematics for the secondary school; in the third year calculus; and in the fourth year, mathematical theory, including the history and philosophy of mathematics and methods of teaching. The chief and underlying purpose of these courses of study is informational, cultural, and disciplinary. It undertakes to enlarge the student's knowledge and understanding of the field of mathematics; to quicken his intellectual interest in its character and its power; to give him a keen appreciation of the processes of thought required and their important relations to the life of everyone, as well as to develop in him skill in making use of this mode of thinking. It should result in exactness of statement, in definiteness of speech, in clear, precise and logical thinking, and in a profound respect for accuracy and truth. It

should enable the prospective teacher to gain a realization of the broad scope of mathematics and its almost limitless applications in present day life, and at the same time an understanding of the relationships among the narrower divisions of the subject as studied in the high school.

2. Acquaintance with the History and Philosophy of Mathematics

The teacher of mathematics needs something more than a mastery of subject-matter and skill in the processes of the subject, even though the scope of subject-matter is much more extensive than will be required in the actual courses which the high school teacher will be called upon to teach. He needs also an understanding and an appreciation of the significance of the mathematical mode of thinking, and a knowledge of the historical development of the subject. It may be said that a mastery of a subject implies a knowledge of its history and philosophy. If so understood I will accept that understanding, but I do not think that is usually taken for granted. For that reason I wish to make special mention of the need of this knowledge. To know the origin and development of mathematical terms, processes and symbols, the growth and establishment of mathematics as a mode of thinking, its evolution through the years, its significance in the progress of civilization, its importance to science and to the thought processes of the past and of the present; its essential relationship to an adequate interpretation of life—to have an understanding of these aspects of mathematics is to possess an expert knowledge of the subject and an intimate acquaintance with its meaning and value, which will go far toward making the teacher more than usually capable in his field. We believe that as much as possible should be done for the student in giving him an understanding of these aspects of his field. The more thoroughly he knows them, the better teacher he will be, and without a good grasp of them, he cannot hope to become more than a drill-master.

3. Review of the Mathematics of the Secondary School

Either immediately preceding the study of the methods of teaching mathematics or simultaneously with that study, a rapid review is made of secondary school mathematics, particularly algebra and geometry. From the college student's more ma-

ture point of view, and in the light of added mathematical knowledge, the student gains from this study a new understanding of mathematics. Perhaps for the first time, and certainly more clearly than ever before, he has a realizing sense of the meaning of mathematics and the value and purpose of teaching it. He sees the symbols and formulas as signs representative of something more profound; viz., the logic, the method, the way of thinking or reasoning that underlies them; he appreciates the place and value of accuracy in reading, in observation, in computation, in recording; he realizes the need in all our thinking of arrangement and order and system; and even recognizes the influence of the mathematical idea, once grasped, upon our use of language, our clearness of purpose, our standards of achievement, our reliability of judgment. This review adds to the feeling of mastery on the part of the prospective teacher; it serves to strengthen the foundation of his scholarship and gives him in a renewed acquaintance with a field of study already studied and acquired, the necessary equipment of familiar knowledge and a confidence in that knowledge which is reinforced by the added knowledge of advanced mathematics, all of which serves to enable him to approach his work as a secondary school teacher with far greater prospect of success.

4. Study of the Teaching of Mathematics

An important part of the preparation for teaching mathematics is the student-teaching under supervision. Immediately preceding this experience, special attention is given to the study of the teaching of mathematics. While the mastery of the subject-matter is one essential, it is not the sole essential. We believe that there is needed also an understanding of psychology and the laws of learning; an acquaintance with the scope, content and organization of the courses in mathematics offered in the secondary school; a knowledge of the methods of teaching that are adaptable to this field and of the appropriate presentation and conduct of various types of lessons; of the effective use of illustrative materials and an ability to judge and to use textbooks and reference books. By reason of this training in methods of teaching the student should gain some ability to analyze teaching problems and situations that arise, and to be able to employ the appropriate procedures in their solution. In short he should acquire a definite understanding of the processes of teaching upon which teaching skill may be successfully built.

5. Student-Teaching of Mathematics Under Supervision

This experience of actual teaching of a subject is, in our opinion, an essential part of the preparation of a teacher. It is as necessary as the interneship in the preparation of a physician or of an apprenticeship in the preparation of a mechanical engineer. For more than a half-century we have had the privilege of furnishing our students this experience in the public schools of Worcester. We have had a friendly arrangement with the city school authorities whereby our students are given the opportunity of teaching regular classes under the normal conditions of the school. They do this under the instruction and general oversight of our own supervisors; and during a period of 9 weeks in the junior year, they are given full charge of the daily class work in the subject that is assigned to them. We have also a small training school of our own, of junior high school grades, in which they do the full instruction. Here they teach their major subjects for a period of 12 weeks in their senior year. Their teaching is observed by the supervisors as frequently as possible, usually every day in the training school; and is followed by an individual conference for criticism and instruction. The supervisors direct the making of lesson plans, examine the written work, and guide the training of the student-teacher in such matters as determining aims, questioning, learning the different types of lessons and the appropriate procedures in conducting them. By this practical experience under natural teaching conditions, the students make rapid progress in the development of their teaching ability; their scholarship is tested; they gain a new understanding of the subject-matter which they teach, and how to organize it and present it; they acquire the teacher's point of view and an ability to evaluate good methods of teaching; they are enabled to appreciate the problems of management and to understand the value of maintaining attention and interest. In our judgment this experience of student-teaching is one of the most valuable factors in the preparation for teaching, and we believe that it contributes immeasurably to the promise of success to those who look forward to teaching mathematics in the secondary school.

6. Assembly Exercises Based on Studies in Mathematics

As a factor in the preparation for teaching any subject, the

value of training in speaking from the platform before the assembly of students is very great. Such practice makes for growth in ease, precision and effectiveness in speech. We strive, therefore, to give opportunity to the students in all departments of our work to get this practice. Those who major in mathematics participate in it and give frequent programs illustrative of their studies. These programs comprise chiefly the reading of papers, with or without charts, and the use of illustrative materials; also discussions of individual investigations, of the scientific and industrial applications of mathematics; of the origins and the development of formulas, symbols and ideas; also the reporting of particular cases of teaching problems experienced by the students in their teaching practice, and other significant phases of this important subject. It is our conviction that it is valuable training and we believe that it is highly regarded as such by the students themselves.

By this brief outline it has been our aim to give a general understanding of the extent and character of the preparation afforded in this institution for the teaching of mathematics in secondary schools. The quality of the work done in any field is affected in no small degree by the instructors in charge of it. It is no less true in this case. The work in this field is conducted by two instructors who are familiar, by teaching and administrative experience, with the conditions of high school teaching, and who are interested in contributing to their improvement. They are both enthusiastic teachers, who take pride in their chosen field of teaching; scholarly in their approach to the subject and in their conduct of it, thoroughly prepared, broad in their views and possessing the highest standards for teacher-training work. They are qualified to fit the work in training to the needs of the prospective high school teacher of mathematics, and the outcomes of their instruction may be described in brief as follows: An adequate understanding of the subject-matter of the field of mathematics; an appreciation of its significance in the life of today; an acquaintance with the theory and problems of teaching it; and a proved ability to teach it in the secondary school. Those of our graduates who have majored in this field and have undertaken this preparation for the teaching of mathematics have, we believe, gone out with an excellent promise of success.

THE FLORIDA FRUIT AND VEGETABLE REGION

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The very title, "The Florida Fruit and Vegetable Region" as given in the text, *The United States and Canada,* by Harlan H. Barrows and Edith P. Parker, appeals to fifth grade pupils. In a study of this unit made recently in the Laboratory School of the State Teachers College at Emporia, Kansas, one of the first objectives was to write on the board the items suggested to members of the class on hearing the words, "The Florida Fruit and Vegetable Region." Since practically all children know that some of the winter fruits and vegetables seen in grocery windows are produced in Florida, it took very little time to build quite a lengthy list. When there was a question concerning the places from which some of the foods come, it was suggested that the pupils go to the grocery in order to learn more about the source of the foods that they happened to have noticed. They enjoyed reading from a large pictorial map four feet square that is published by the Department of Agriculture at Tallahassee. Even though certain products are greatly enlarged, information gained from this map has value.

Linked with the first objective was a second concerning the giving of reasons for the production of the fruits and vegetables listed. The average fifth grade pupil knows that since Florida is nearer the equator than other states of the nation, the growing season must be long. Certain of these pupils knew that it is so long in the southern part of the state that it rarely frosts. From the rainfall map they read that each year the precipitation is about sixty inches. Another map showed that most of the land is low and flat.

Before relationships were stated, the pupils began reading other items from the large map published by the Department of Agriculture. Even though the fish are as large as the boats, the pupils saw that there are opportunities for recreation and they recalled that certain children went to Florida to spend the winter. Here again the understanding of warm days was strengthened. Once a slight understanding of the state as a winter playground was gained, the suggestion was made concerning two activities carried on in Florida that are pictured on the map but that had not been mentioned. The collecting of

naval stores was read with little difficulty but no one was able to recognize the activity carried on in a building east of Tampa that resembles a breaker house seen near coal mines. Since the pupils failed to read the item about the production of phosphate they were sent to their texts to read the entire section on the Florida Fruit and Vegetable Region with the suggestion that they not only learn about the mining industry but that they also learn more about the production of items listed on the board. Very soon hands were raised acclaiming the fact that there are phosphate mines in Florida and that Florida ranks high in phosphate production. Phosphate makes up seventy five per cent of the mineral production of the state. At this time the teacher made known the fact that Florida leads the world in its production and that quantities of phosphate along with imported nitrate and other fertilizers are used on the fruit and vegetable gardens of Florida. The best picture available of phosphate works is found on page 42 of Volume LVII of the *National Geographic* for January, 1930. The article, "Florida, the Fountain of Youth," by John Oliver Gorce contains a great deal of general material that is worth reading.

Since agriculture is the most important industry, the section on truck farming was carefully considered and someone suggested that it would be very easy to make a graph showing the production of Irish potatoes amounting to more than five million dollars; tomatoes, four; sweet potatoes, three; celery, two; and lettuce, cucumbers, cabbage, and beans, between one and two million dollars annually. This work was followed by the reading of "Winter Gardens" in *North America by Plane and Train* written by Allison E. Aitchison and Marguerite Uttley.[1] Here in the form of a diary written by the owners of Inwood Farm, the story about truck farming is interestingly told. Activities carried on on the farm from the last of December to the tenth of October are included. On the former date strawberries and tomatoes are ripe and potatoes are ready for market. Winter in Florida is likely to be a month of heavy rainfall. The spring months will possibly be dry. In this land considered by some to be topsy-turvy, people work out of doors twelve months of the year. Harvesting may be carried on during the winter and spring months.

[1] Some of the more rapid readers read from the references: "Nearing the Tropic Zone" in *Our Own United States* by Walter Lefferts; "A Semi-Tropical Region—The Florida Peninsula," pages 11–15 of *North America and South America* by G. R. Bodley and E. L. Thurston; and pages 106–109 of *Our Home State and Continent* by Albert Perry Brigham and Charles MacFarlane.

Attention was called to the marketing of products grown since it proves to be as interesting as the growing and the harvesting. The work of the United States Weather Bureau in keeping shippers informed as to weather conditions as products are hurried northward to market even at zero temperature was found worthy of consideration. Since a detailed study of citrus fruits was made while studying California, pupils built on what they already knew. They made many comparisons in this part of the study. They knew that oranges are grown in Florida, but they were surprised to notice that where they are produced in southern California under arid conditions they are produced in Florida where rather humid conditions prevail. A student teacher observed that the Indian River brand there takes the place of the well-known Sunkist packed in California, the rival state. Sections of "How New York is Fed by Florida" written by C. L. Brown in *Florida Sunbeams* published by the State Bureau of Immigration and the Department of Agriculture were read to the class.

In considering production in southern Florida, the possibility of reclaiming the Everglades appeared. Pupils noticed that in reaching this area, much of which is only twenty feet above the sea, they would pass near Lake Okeechobee, one of the 35,000 fresh water lakes in Florida, and the largest body of fresh water wholly within the United States. A few alligators, that are killed for both their teeth and their skins, were seen near the Lake. Attention was called to the herons, pelicans, and cranes that might be seen. When the boggy Everglades with their sharp edged saw grass were finally reached, reclaiming them as land is reclaimed in Holland was suggested. The pupils found the water situation to be bad as there are under ground springs. When the rainfall is heavy, Lake Okeechobee having an area of nearly seven hundred fifty square miles at normal stage, breaks its low barriers and overflows.

Pupils understood that in this part of Florida, even though there rarely is a killing frost, production will perhaps never be great unless the soil undergoes treatment. They enjoyed learning about the Seminole Indians who live in the Everglade Region. There are interesting articles in *The Home Geographic Monthly* for September, 1932, and in *World's Work* for February, 1931, about them. The latest census report indicates that

there are now less than five hundred of these Indians.[2] Living in their palmetto houses in this semi-tropical land, they love seclusion. The Seminoles are largely farmers; many carry on simple household arts.

After a general summary of the work covered on agriculture in Florida, the objective was to turn again to the pictorial map. The pupils realized that very little had been said about fishing, an industry that occasionally adds as much as $15,000,000 to the annual income. A small amount of time was given to fishing for mackerel, shad, mullet, and the large tarpon. The major interest of this class was in the peculiar looking round objects that some member of the class recognized as sponges. Perhaps the best story about this soft skeleton framework which has been deserted by its inhabitants is given in Volume LIX, page 40 of *Travel*, for May 1932. "*I Travel Sponge Fishing* in the Florida Keys" by Margaret Starr Parker is well written.[3] She calls attention to the fact that Tarpon Springs on a small stream flowing into the Gulf is the largest sponge market in the world. Thousands of dollars worth of sponges are drying everywhere on the docks. Some twenty years ago Greek laborers who were skilled in the industry at home came to Florida. They now have a fleet of fifty-five diving and thirty-five hooker boats. Sometimes divers work in the water at a depth of a hundred fifty feet. When they are brought from the sea, the sponges contain slimy living animals. They increase in diameter about an inch a year. An eight inch sponge is perhaps about six years old. The greatest number of openings are on the upper side of the sponge. Exposure to the air reduces the living tissue within. Men working at the surface of the water use three-tined hooks fastened to a fifty foot pole. They anchor their larger boats and work in pairs from small row boats. The sponges, varying in color from yellow to black, are washed in salt water, clipped, threaded on strings, and hung to dry and bleach before they are sent to the warehouse.

After summarizing points learned about fishing including the sponge fishing industry it was very easy to lead into the consideration of Florida as a winter resort. In many parts of Florida

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[2] The map on page 161 of the *New World* by McMurray and Parkins leads one to believe that the distribution of population on this part of the state is about as great as elsewhere.

[3] Page 47 of *North America and South America* by Bodley and Thurston; page 108 of *Our Home State and Continent* by Brigham and McFarlane; page 110 of *Living in the Americas* by McConnell show interesting pictures. Pages 71 to 73 of *North America* by Nellie Allen include a picture as well as interesting subject matter.

population in the winter time is greater than that of the summer season. Some child suggested that a visit be made to the resorts by starting with Jacksonville and continuing around the peninsula to Pensacola or vice versa. The pupils had learned about Jacksonville as a commercial center for the shipping of fruits and vegetables; however a special trip was made to this, the largest city. The pupils learned that Jacksonville, a city of 130,000 is known as the "Gateway of Florida." It is about twenty-two miles from the Atlantic on the St. Johns River, a bankless stream that is navigable for about two hundred fifty miles. The proposed Jacksonville Port Inglis Canal will make use of the rivers and lakes as it is cut across the peninsula. This will save two and a half days sailing from the trip around Florida. A plan for the $146,000,000 project was shown in a September issue of the *Kansas City Times*. The completion of this project should add to the trade of Jacksonville, where barrels of naval stores, crates of strawberries, and boxes of oranges, grape fruit, and lemons were seen at the docks. These products told something about what is going on in the hinterland. A good picture of Jacksonville is shown on page 106 of "Our Home State and Continent" by Brigham and McFarlane, Volume LVII of the *National Geographic*, also contains pictures that are worth while.

A visit to the Jacksonville area would hardly be complete without a trip to St. Augustine, the oldest city in the United States, established in 1565. The stucco houses of Spanish architecture surrounded by palmetto and other trees, with their Spanish moss, make it a beautiful spot. The climate is fairly comfortable and invigorating.

The pupils found that the well-known Ormond-Daytona highway is thirty-five miles in length. A trip over the wide expanse of white sand is enjoyable. It is at Ormond that John D. Rockefeller has built a tropical home near a lagoon on the Halifax River.

A great deal of the material given on the cities of Florida had to be told by the teacher. The work was correlated with work in language through the writing of letters to railway companies.[4]

Palm Beach the queen of American resorts, a winter paradise, has been built on a narrow strip of land. Outdoor life in-

[4] There is good descriptive material of interesting places in Florida in folders published by The Illinois Central Railway and The Southern Railway System Both have offices at Seventh and Walnut Street in Kansas City. The Atlantic Coast Line Railway, having an office at 138 West Bay Street, Jacksonville, Florida, also publishes several interesting pamphlets.

cluding golfing, bathing and yachting, contrast with a life in the villas, casinos, and bath houses. Normal winter temperatures are rarely lower than seventy degrees. Palm Beach is pictured on pages 88 and 89 of the *Geographic*.

Miami with its wide sandy beach suggested Atlantic City. Before 1911, it was a sub-tropical jungle, but now it is known as "The Magic City." Pages 88 and 89 of the *National Geographic* previously mentioned picture the commodious harbor that is occasionally swept by hurricanes. The Beach is connected with Miami by a long causeway.

Before visiting the west coast cities, pupils chose to go to Key West, the "Land of Cocoanut Palms." This is an ideal vacation spot. One author has said that Key West is worth going to just for the fun of getting there. This southernmost city of the United States is reached by a hundred twenty-five mile railway that is built on trestles. The work was completed after nine years of labor. Concrete arches extending from key to key have brought them much nearer to the United States. The railway is pictured on page 11 of *North America and South America* by G. R. Bodley and E. L. Thurston, and on pages 68 and 69 of the number of the *National Geographic* previously mentioned.

Tampa, the Seminole for "splitwood for quick fires" is the leading commercial center on the west coast. Several pictures of the city are given in the *National Geographic* for January, 1930. This is one of the cities claiming an early visit from De Soto. The Tampa Hotel built along Moorish lines and costing $53,000,000 is an attraction. The more practical minded would visit the docks where phosphate, rosin, turpentine, lumber, citrus fruits, cigars, and sponges await ships. Practically everyone would enjoy a visit to the Singing Tower and to St. Petersburg the "Sunshine City" that has chosen the poinsettia for its flower. This city is the terminus of the Atlantic Coast Line Railway. On the return trip to Kansas, several pupils chose to visit Tallahassee and Pensacola. The latter city is so far from the others that it stands alone as a resort. It is pictured on page 21 of the *National Geographic*.

In summarizing the work on resort places, the pupils sketched the state with its fifteen hundred miles of coast line. The names of the many resort centers were placed in their proper location around the rim of the state. The pupils enjoyed a closing exercise checking statements with a plus or minus. Outcomes showed that they had not only learned about production in the

country and reasons for it but that they had gained a favorable attitude toward the problems of the people. The statements follow:

1. Vegetables are sent from Florida for Christmas markets in the North.
2. Tampa leads all other cities in the export of cigars.
3. The best known winter resorts on the east coast of Florida are connected by a splendid system of highways along the beach.
4. Mild temperatures and many possibilities for recreation call people to Florida in the winter time.
5. Low elevation and the presence of small streams and lakes would make the digging of the Jacksonville-Port Inglis Canal fairly easy.
6. High temperatures in Florida help to explain the production of winter wheat.
7. Nearness to the surface and nearness to seaports help to make the shipping of phosphate easy.
8. Jacksonville, the largest city, is located on the gulf coast of Florida.
9. Miami leads all other cities in the export of naval stores.
10. The building of the railway to Key West shortened the distance between the islands and the mainland.
11. Numerous sponges attached to the sea floor near Florida make sponge fishing profitable.
12. A growing season of less than five months helps to explain the production of winter fruits and vegetables.
13. The growing of citrus fruits is made possible by the presence of streams supplying water necessary for irrigation.
14. High elevations and great distance from the equator explain why Florida is a winter playground.
15. Phosphate production in Florida makes it unnecessary to import other fertilizers.
16. Rains coming in the autumn months help to explain the growing of cotton in Florida.

PRESENT DROUGHT CYCLE NEARLY ENDED; NEXT ONE NOT DUE UNTIL 1975

Drought years are nearly at an end for the United States. They will not return until 1975. Such is the forecast of Dr. Charles G. Abbot, secretary of the Smithsonian Institution, made before the meeting of the American Geophysical Union. He said: "We seem justified in expecting a recovery from drought conditions in the Northwest within a year or two, but a severe recurrence of them following the year 1975."

This is based on the 23-year cycle in solar activities and weather on earth, long a subject of special study by Dr. Abbot. A double period, a cycle of 46 years, "appears to be particularly important in precipitation," the Smithsonian head declared. It seems to have recurred regularly, affecting tree-ring widths . . . for four centuries. Its recurrence is in nearly the same phase as the variations of level of the Great Lakes for the past century."

The 23- and 46-year cycles have also appeared in temperature departures from normal in such widely separated regions as western Europe, South Africa and Australia.

TELLING THE TRUTH IN ELEMENTARY SCIENCE

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Science teaching has a history of many enthusiasms; correlation, integration, project method, the unit plan, the child-centered course, the psychological approach have all been intended to teach most effectively and least painfully the knowledge of the sciences. In the elementary schools today there are advocates of nature study and of elementary science presenting opposing points of view concerning the approach to science. The proponents of each one of these methods have had worthy objectives; but often they have gone to extremes, led by a missionary zeal not guided by sound training in the sciences they profess. No method, and no sloganized phrasing can take the place of a learned teacher who is able to give accurate statements and answers to questions involving complex phenomena, in terms that the young student can understand and appreciate. In other words, it is only the well-trained, intellectually honest teacher who can tell the truth to pupils in elementary science.

The literature of elementary science and nature study has a number of persistent inaccuracies that should be corrected. I would like to call attention to a few of these that are concerned with the study of plants. The statement is often made that plants breathe, and that they have breathing pores in their leaves. Plants do not have muscles with which to make breathing movements, or lungs and blood as a source of an internal supply of oxygen, as many animals have; the oxidation process of respiration to which the misstatement refers is a fundamental life process that occurs in every living cell of *all plants and animals*. The idea still persists, also, that the balance in nature of the carbon dioxide-oxygen cycle is maintained by the plants' use of CO_2 and release of O_2 and by the animals' use of oxygen and release of carbon dioxide, which the plants in turn use. The resulting concept in the students' minds is that "plants breathe in CO_2 and release O_2 and animals breathe in O_2 and release CO_2 'for' the plants to use." This mistake is avoided when it is made clear by books and teachers that the process of photosynthesis in *green* plants in the light uses CO_2 and releases O_2, and that it is balanced by the process of res-

piration in *both plants and animals* and by other oxidations that use O_2 and release CO_2. The important point that photosynthesis is the storing of energy, which may be released later by respiration as active energy in the work of the living cell, should often receive more stress.

Another of the topics often used in elementary science teaching is the scattering of the seeds and fruits of plants by various agencies. The topic has been given the title "How Plants Scatter Their Seeds." A major error that occurs in this teaching is the inclusion in the list of seeds the *fruits* of dandelion, beggar-ticks, burdock, Spanish needles, and many others. The importance of structural botany is here quite evident, for the teacher must know what a fruit is and what a seed is to be able to recognize each structure. But the error even more important in scientific thinking is that plants *do not* scatter their seeds, with the few exceptions illustrated by witch hazel, the famed "exploding" cucumber, and touch-me-not, whose seeds are thrown out by the sudden opening of the fruit—a process over which the plant exerts no purposeful control. An important problem needing careful watching in the teaching of this topic is that of avoiding questions that lead to teleological answers. Such a question as was suggested for fourth grade pupils, "do you know why plants must scatter their seeds?" can receive only a teleological answer and leads students away from science instead of toward science as a technique in thinking. The seeds and fruits of plants are scattered in most instances by external agencies, and although many cases of this are interesting and important, the process and structures concerned in the process do not involve will or purpose on the part of the plant.

Such important errors as confusing fundamental processes, incorrect naming of readily determined structures, and the asking of questions that implant the idea of consciousness and purpose as causative factors in plant behavior lead one to the conclusion that, although the science of the elementary grades must be presented according to age levels, the science training of the teacher must be far more than elementary.

SAN FRANCISCO-OAKLAND BRIDGE SIGNALS

On the San Francisco-Oakland Bridge there are 32 automatic signals along each side for use by motorists whose cars may be stalled while crossing. Breaking the glass in the signal box summons a tow car.

TREES AND FOREST CONSERVATION

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METHODS—MATERIALS—APPARATUS—TECHNIQUES

The unit on *Trees and Forest Conservation* was prepared with the major objectives now generally recognized as paramount in botany constantly in mind. After the main divisions and topics of the unit had been worked out, they were analyzed from the standpoint of *efficient methods of presentation*. The specific methods and techniques used in presenting a subject naturally depend upon the type of the subject matter. Field trips, preserved specimens and the microscope, supplemented by herbariums, museums, models, pictures and graphs have long been used by the biologist because the study of plants and animals was made clear through these media. Obviously it was natural for the botanist and zoologist to accept motion pictures, slides and film-slides to supplement their other visual material, the value of which had already been established for the study of plants and animals.

The method generally accepted as the best one, for the study of plants (trees in this particular unit) is to observe them directly in the field. This method was used as extensively as possible in *learning to know* various trees. However, many obstacles are always encountered on field trips. Some of these obstacles, familiar to every one that has conducted field trips, are: interference with class schedules (class periods too short, etc.), distances to desired material too great, inclement weather, etc. Fifty different trees are studied directly in the field in completing Part I of this unit. Because of the obstacles mentioned, it is impossible in many of the cases to study the tree as long as desirable or to revisit the scene for review. Visual aids, in the form of mounted herbarium specimens and pictures, were the logical media to supplement the field trips.

To efficiently supplement the local field work, it is necessary for the teacher to personally prepare the pictures. Equipment was purchased with this end in view. This equipment consisted of two cameras that use 35 mm. film and produce pictures that may be projected, without enlarging or reducing, in the standard commercial 35 mm. film-slide projectors. Special supple-

mentary lens were added to the equipment so that "close-ups" could be taken at distances of 14 3/4 inches, 8 inches, and 6 inches. A "copying unit" and standard were obtained to facilitate the taking of "close-ups" of buds, twigs, leaves, flowers, fruits and seeds, of other photographs, and of material through the microscope.

After a survey of the different film-slide projectors, one was chosen that had a microscope slide carrier as optional accessory exuipment. This type of machine was decided upon because of its increased flexibility as compared to projectors equipped only with the film-strip unit. It was found that it does not make for efficiency to be restricted to one definite sequence of pictures, when using visual material to supplement field work. Some of the circumstances or needs that make several arrangements of the pictures necessary, are: review (or preview) of trees of one certain trip, presenting the trees that are "causing difficulty," grouping the tree pictures into "Families" for review (Elm Family, Maple Family, etc.), comparison of certain structures of various trees, as—leaves, twigs, types of branching, bark, flowers, fruits and seeds.

A satisfactory technique for preparing "glass slides" for projection with the microscope slide carrier equipment, that makes many arrangements of pictures possible, has been worked out. A section of film with an opaque border is fixed between two thin microscope slides which are held firmly together with binding tape. These slides have the advantages of small size (they may be filed in regular microscope slide boxes) and of low cost as compared to the regulation projection slides. Tests for heat resistance have shown that slides may be left in the projector for five or more minutes with no apparent damage to the enclosed film.

Part II *Forest Conservation*, deals with the relation of forest products, and the depletion, protection and renewal of forests to the economic and social welfare of mankind. The impossibility of observing directly, the different types of forests in the United States and the various topics mentioned above, in connection with conservation, is obvious. Verbal and reading descriptions are inefficient and often entirely ineffective without a sufficient visual apperceptive mass on the part of the pupil. Slides, film-slides and moving pictures, carefully selected to form a definite and integral part of this unit of study, have been found to form not only a good foundation, but also to serve as an ex-

cellent motivation for continued interest and study. Much of this "foundation" material along with many excellent forestry bulletins may be obtained from the United States Department of Agriculture, Washington, D. C., at a very nominal cost or in some instances by merely paying express charges.

General Outline of the Unit

Part I. Learning to know trees

A. Identification.
B. Various conditions in which trees live.
C. Structures and functions of various parts of the tree which enable it to live in changing conditions.
D. Relation of trees to the home—landscaping, fruit trees, etc.—including transplanting, pruning, grafting and care of wounds.

Part II. Forest Conservation

A. Products of the forest.
B. Protective influences.
C. Depletion of forest resources.
D. Wise use and protection of forest resources.
E. How forests are being renewed.

Part I. Learning to know trees

A. *Identification*

1. Preliminary survey of several trees around school to show the necessity of knowing parts, some descriptive terms, etc., in order to learn to *know* trees.
2. Parts of trees, items to look for in identification, terms, etc., studied in the laboratory. Film-slides, mounted leaves, twigs, etc., used to illustrate this work.
3. Field trips—to study trees.
   a. Pictures (i.e., film-slides) of the trees observed on the trips are studied in the laboratory for review, comparison, and discussion.
   b. Field trips, supplemented by film-slides, mounted materials, specimens of fruits, seeds, etc., are continued during the course of this *entire unit* as conditions permit.

B. *Various conditions in which trees live*

Conditions are included, along with the types of trees in the various habitats, that can not be studied via local field trips. Various conditions include *hot*, *cold*, *dry*, *moist* habitats, diseases to combat, etc.

Material to cover the conditions that can not be observed directly by the means of local field trips include the following two film-strips:

(1) *Forest Botany*
Spencer Lens Company, Buffalo, N. Y.

(2) *The Life of a Tree*
Spencer Lens Company, Buffalo, N. Y.

C. *Structures and functions of various parts of the tree which enable it to live in changing conditions.*

An overview of structures and functions of various parts of the tree is excellently presented in the moving picture film (16 mm., silent), *A.B.C. of Forestry*, Department of Agriculture, Division of Motion Pictures, U. S. Government, Washington.

This film briefly takes up the structures and functions of the roots, stems and leaves (not very complete on leaves). Annual rings are shown and explained as well as the reason for lower branches falling off as height increases. Other topics included near the end of the film are: selective logging, how to fell a tree, how to plant a tree, humus and its relation to water, and several results of fires.

D. *Relation of trees to the home,—landscaping, fruit trees, etc.—including transplanting, pruning, grafting and care of wounds.*

Supplementary material concerning this phase of the work, included the following film-strips:

(1) *Transplanting Trees and Shrubs*
Film-strip, No. 176, United States Dept. of Agriculture, Extension Service, Washington, D. C.

(2) *Grafting and Budding Fruit Trees*
Film-strip, No. 197, United States Dept. of Agriculture Extension Service, Washington, D. C.

Part II. Forest Conservation

An excellent introductory over-view to Part II is presented in the film-strip, *Forest Conservation*, prepared by the United States Department of Agriculture, Washington. The slides include the following topics and sub-topics that may be used as bases for more intensive investigation:

A. *Products of the Forest*

Examples:
1. Employment
2. Pines—rosin and turpentine
3. Paper—boards, etc. from wood pulp
4. Rayon and cellophane
5. By-products of wood
6. Forest grazing
7. Camping
8. Wild life
9. Water

B. *Protective Influences*

Sub-topics
1. Protects water sheds
2. Trees hold soil on steep hillsides
3. Trees hold sand dunes, etc.
4. Trees act as windbreaks

C. *Depletion of Forest Resources*

Sub-topics
1. Wrong methods of lumbering, and waste in use of wood at factories
2. Fire
3. Insects
4. Fungus diseases

D. *Wise (Proper) Use and Protection of Forest Resources*

1. Reasons for National Forests
   a. National forests used as a crop
   b. Forest officers teach proper care of camp fires, etc.
   c. The National Government is making a determined effort to control insects and fungus diseases in the National Forests.

E. *How the Forests are Being Renewed*

Sub-topics

1. Seed trees, planting by nature
2. Nurseries, planting by man

After the over-view of Forest Conservation has been presented, each of the main topics (A, *Products;* B, *Protective Influences;* C, *Depletion;* D, *Wise Use of Resources;* E, *Renewal*) is studied as extensively as time permits.

A. *Products of the Forest*

The motion picture films, (1) *Forests and Wealth*, (2) *Pines from Seed to Sawmill*, and (3) *Forest and Water*, Department of Agriculture, Extension Division, Washington, present well organized factual material concerning products of forests and the relation of these products to social activity. A brief resume of each of these three films is given below.

(1) *Forests and Wealth*

Motion picture film, 16 mm., silent,
Dept. of Agriculture, Extension Div., Washington

This film shows that man's increasing need, for success and progress, has been met by the forest through the ages. Man's dependence upon the products of the forest from Biblical times to and including the development of America is successively portrayed.

(2) *Pines from Seed to Sawmill*

Motion picture film, 16 mm., silent,
Dept. of Agriculture, Extension Div., Washington

The successful transition of the "old south" with its plantation life, to the "new industrial south," a southland more prosperous than ever before, is shown to be dependent upon the correct use of the forests and lands suitable for forests. This film shows the south to be one of the most profitable timber growing areas in the United States because of its long growing season, rapidity of tree growth, due to moisture and temperature, and proximity to large eastern industrial centers, markets, and sea ports. Illustration show that the forests of the south now provide work in 5,400 saw mills, 1,200 turpentine factories, in addition to employment in lumbering, transportation, manufacturing of various products, building, etc. The correct procedure and necessity for protecting the forests from "enemies" and for using the forests as a 'crop' so that the benefits may continue and permanent prosperity result, are excellently portrayed.

(3) *Forests and Water*

Motion picture film, 16 mm., silent,
Dept. of Agriculture, Extension Div., Washington

The entire content of the film, *Forests and Water*, is based on the following important fact, "From the forest comes water that is life to mankind." The ability of the forest to conserve moisture is shown to be dependent upon the humus of the forest floor. The water holding capacity of the humus, as compared to that of bare soil, is portrayed in a very striking and impressive manner. The final scenes show the forest to be the origin of permanent streams that make for cheap transportation and electric power, and that when the forests are destroyed, devastating droughts, destructive floods and a sterile gullied land, result.

B. *Protective Influences*

The following two series of film-slides depict in detail, very important phases of the protective influences of trees:

(1) *Farm Shelterbelts in the Plains Region*
Film-strip, No. 387, United States Dept. of Agriculture, Extension Service, Washington

(2) *Stop Gullies—Save Your Farm*
Film-strip, No. 341, United States Dept. of Agriculture, Extension Service, Washington

****Notation*—The motion picture film, *Forests and Water*, is worth reviewing, since it points out the relation of the protective features of the forest to a permanent water supply, along with the protection against droughts, floods, and erosion.

C. *Depletion of Forest Resources*

The film-slide, *Enemies of the Forest*, Spencer Lens Co., Buffalo, N. Y., presents most of the destructive agencies of forests in a very concise manner. This material adapts itself excellently as an introduction to this phase of the study. The outstanding "enemies" of the forests, depicted by this film-strip, are:

**1. Forest fire*
**2. Fungus*
**3. Insects*

Examples:
a. Gypsy Moth
b. White Marked Tussock Moth
c. Leopard Moth
d. Hickory Bark Beetle
e. Tent Caterpillar

The "enemies" of secondary importance, depicted in this series of pictures are:

4. Impure air—copper mines
5. Blow-down
6. Snow slide
7. Frost crack
8. Lightning

(**1&2*) The forest destroying agencies, fire and fungi, deserve detailed consideration in any botany unit on Reforestation. Material on these subjects should be vivid so as to bring about thoughtful consideration and to make a lasting impression.

**1. Forest fire*

The United States Dept. of Agriculture, Washington, has several motion picture films on *Forest Fires*. Two of the films are particularly important for this unit because they not only vividly illustrate prevention, cause, rapidity of spreading, and methods of combating forest fires, but also the disastrous after effects, as floods, droughts, and erosion. The two films, that include this very important information, are:

(1) *What Price Fire?*, 16 mm., silent
(2) *It Might Have Been You*, 16 mm., silent

**2. Fungus*

The following series of film-slides illustrate in detail, two of the many serious fungus diseases, and show what the government is doing and what individuals can do to combat various tree diseases.

(1) *Saving Our Pines From Blister Rust*
Film-strip, No. 370, United States Dept. of Agriculture, Extension Service, Washington

(2) *Chestnut Blight*
Film-strip, No. 199, United States Dept. of Agriculture, Extension Service, Washington

D. *Wise Use and Protection of Forest Resources*

The subject of wise use and protection of forest resources is emphasized and studied as an integral part of the first three divisions of Forest Conservation (A, Products; B, Protective Influences; C, Depletion).

E. *How Forests are Being Renewed*

The necessity of and methods of forest renewal are illustrated in the film-slide, (1) *Forest Planting In The Northeastern States*, and in the motion picture film, (2) *Future Forest Giants*.

(1) *Forest Planting In The Northeastern States*
Film-strip, No. 216, United States Dept. of Agriculture, Extension Service, Washington

(2) *Future Forest Giants*
Motion picture film, 16 mm., silent, Dept. of Agriculture, Extension Division, Washington.

This film illustrates how nature soon provides new forests, providing some trees are left to scatter seeds after logging operations. However, where forest fires have entirely destroyed nature's growth, trees must be planted by man. Scenes taken in the Savenac Nursery, the largest one owned by the U. S. Government, show in detail the many operations (gathering the seed, planting, transplanting, protection of young seedlings from intense light, weeds, etc.) in preparing young trees for planting in previously wooded areas. One scene, that is of special interest to pupils, shows how one man, by present-day methods of efficiency, transplants 25,000 seedlings in one day.

SUPPLEMENTARY READING MATERIAL

The unit, Trees and Forest Conservation, opens a great many avenues of study for individual interests of different pupils. Varied questions concerning trees and forestry usually arise early in the study of the unit. Consequently, in addition to textbooks and materials that may be ordinarily obtained in libraries, forestry bulletins and leaflets, prepared by the Forestry Division of the United States Government, have been placed on file in the laboratory.

Bulletins of the United States Dept. of Agriculture

	No.
Forestry and Farm Income	1117
Apple powdery mildew	1120
Growing hardwood seedlings	1123
Measuring and marketing timber	1210
Gullies, how to control	1234
Apple-orchard renovation	1286
Pruning citrus trees	1333
Citrus fruits in Gulf States	1343
Apple growing east of the Mississippi River	1360
Bridge grafting	1369
Apple scald	1380
Wind break as a farm asset	1405
Growing coniferous trees	1453

Selling black walnut timber....1459
Apple scab....1478
Apple blotch....1479
Long-leaf pine primer....1486
Nut-tree propagation....1501
Loblolly pine primer....1517
Orchard irrigation....1518
Peach brown rot and scab....1527
Protection of log cabins, rustic work, and unseasoned wood from insects....1582
Transplanting trees and shrubs....1591
Chestnut blight....1641
Christmas trees a cash crop for the farm....1664
Shortleaf pine....1671
Farmers in Northern States grow timber as money crop....1680
Preparing peaches for the market....1702
Treatment and care of tree wounds....1726

Leaflet Series of Farmers' Bulletins United States Department of Agriculture

No.
Planting southern pine.... 32
Woods burning in the south.... 40
Good naval-stores practice.... 41
Small trees wasteful to cut for saw timber.... 55
Preventing cracks in new wood floors.... 56
Pulpwood production in the northeast.... 57
Why some wood surfaces hold paint longer than others.... 62
More turpentine, less scar, better pine.... 83
Planting black walnut.... 84
Injury to buildings by termites....101

EXPLORERS ASTONISHED—INDIANS BURIED HUGE JADE TREASURE

A 200-pound boulder of jade—a sort of Cullinan Diamond of ancient America—has just been unearthed in ruins of a Mayan pyramid near Guatemala City by an expedition of the Carnegie Institution of Washington.

"We were astounded, for no piece of jade even remotely approaching this in size has ever been found in America before," declared Dr. A. V. Kidder, in charge of the excavations, in reporting the discovery to the Institution here.

The rough ball of jade bears scars where Mayan Indian workers had cut out slices of clear green stone for use in jewelry or ceremonial objects. Why the Indians then buried their treasure at the very center of a pyramid stair is a mystery.

"The whole boulder was of good quality and might have represented a vast value," said Dr. Kidder. "Its burial was doubtless ceremonial; but what a sacrifice! Or, was it for protection, like the cache of gold in Kentucky?"

Modern scientists have searched without success for the natural source where American Indians got their much-treasured jade in Mexico or Central America. The American jade is similar to Oriental jade in appearance, but differs in chemical structure, and in range of coloring.

GEOMETRICAL DERIVATIONS OF THE FORMULAS FOR THE SOLUTION OF OBLIQUE TRIANGLES

By John J. Corliss
De Paul University, Chicago, Illinois

Trigonometry first originated as a geometrical subject. More and more with the passage of time it has become analytical in character. During the past two years I have received eighteen complimentary texts in Trigonometry. Only one of these gives a geometric proof of the tangent law. One introduces the radius of the inscribed circle, by analytic means but gives no hint whatever as to its geometric significance. While I appreciate the power of the analytical method, I also think the subject should retain some of its geometric character. Probably this can best be accomplished in practice by giving both the analytic and the geometric derivation of the formulas wherever practical. In what follows I have outlined briefly geometric derivations of most of the formulas needed for the solution of oblique triangles. Although the results are well known, some of the derivations seem to be new. Several are particularly direct.

The Sine Law:

To derive the formula;

$$\frac{\sin A}{a}=\frac{\sin B}{b}=\frac{\sin C}{c}=\frac{1}{2R}.$$

Let ABC be the given triangle. Draw its circumcircle, the diameter COD, and join D to B. We have

$$\angle CAB=\angle CDB=A$$

and

$$\angle CBD=90°.$$

If R denotes the circumradius then $\sin A=a/2R$ and by cyclic permutation

$$\frac{\sin A}{a}=\frac{\sin B}{b}=\frac{\sin C}{c}=\frac{1}{2R}.$$

The Tangent Law[1] in Symmetric Form:

[1] Geometric proofs of the tangent law are given in Wilczynski and Slaught; "Plane Trigonometry" Breslich and Stone; "Trigonometry" Davies; "Elements of Trigonometry" Funck; "System der abenen Trigonometrie" and in other texts in trigonometry.

To derive the formula;

$$\frac{\tan\dfrac{B-C}{2}}{\tan\dfrac{B+C}{2}}=\frac{\dfrac{b-c}{2}}{\dfrac{b+c}{2}}.$$

Let ABC be the given triangle. Introduce the indirect elements $(b-c)/2$ and $(b+c)/2$ into the figure as follows: On AC take AD equal to AB so that $CD=b-c$. Since triangle ABD is an isosceles triangle the bisector, AM, of $\angle BAD$ is perpendicular to and bisects BD. Hence AMO passes through O, the center to the circumcircle of triangle BDC. The center, O, also lies on the perpendicular bisector, NO, of DC. Then

$$ND=NC=\frac{b-c}{2}$$

$$NA=\frac{b-c}{2}+c=\frac{b+c}{2}.$$

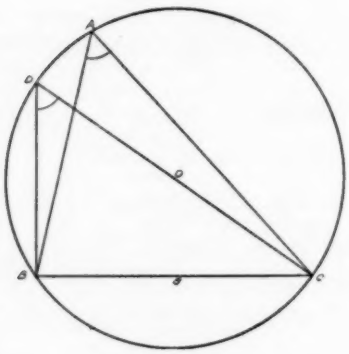


FIG. I

Since M and N are the mid points of BD and CD respectively MN is parallel to BC and equal to $a/2$. Angle $BDC=90°+A/2$, and since the sum of the angles of a triangle is 180° we have

$$\angle DBC=\angle DMN=\frac{B-C}{2}$$

also

$$\angle NOC=\frac{B-C}{2}$$

for it is a central angle measured by $\frac{1}{2}$ arc CD. In right triangle AON,

$$\angle OAN = \frac{A}{2}$$

hence

$$\angle AON = \frac{B+C}{2}.$$

From triangle NOC;

$$\tan \frac{B-C}{2} = \frac{NC}{ON} = \frac{\frac{b-c}{2}}{ON}.$$

From triangle NOA;

$$\tan \frac{B+C}{2} = \frac{NA}{ON} = \frac{\frac{b+c}{2}}{ON}.$$

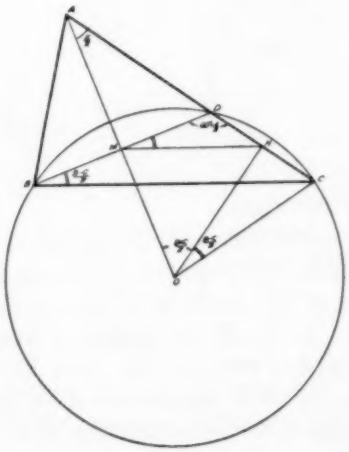


FIG. II

Whence

$$\frac{\tan \frac{B-C}{2}}{\tan \frac{B+C}{2}} = \frac{\frac{b-c}{2}}{\frac{b+c}{2}}.$$

By cyclic permutation or similar analysis we obtain the formulas;

$$\frac{\tan\frac{A-B}{2}}{\tan\frac{A+B}{2}}=\frac{\frac{a-b}{2}}{\frac{a+b}{2}}; \qquad \frac{\tan\frac{A-C}{2}}{\tan\frac{A+C}{2}}=\frac{\frac{a-c}{2}}{\frac{a+c}{2}}.$$

The check formulas commonly called Mollweide's equations[2] follow directly from the figure and the fact that

$$\sin(90°+\theta)=\cos\theta.$$

From triangle MDN;

$$\frac{\sin\frac{B-C}{2}}{\cos\frac{A}{2}}=\frac{\frac{b-c}{2}}{\frac{a}{2}}.$$

From triangle MAN;

$$\frac{\cos\frac{B-C}{2}}{\sin\frac{A}{2}}=\frac{\frac{b+c}{2}}{\frac{a}{2}}.$$

The Half Angle Formulas:

We first prove several necessary geometric relations. Let ABC be the given triangle; I its incenter; I' the excenter with respect to A; r the radius of the incircle; r' the radius of the excircle with respect to A; X, Y, Z the points of tangency of the incircle to the sides a, b, c respectively; and X_1, Y_1, Z_1 the points of tangency of the excircle relative to A to the side a and the sides b and c produced as shown in Fig. III.

Let

$$s=\frac{a+b+c}{2}.$$

---

[2] There is no good reason for calling these Mollweide's equations. Both equations appeared in F. W. von Oppele's *Analysis Trigangulorum* (1746) and in Simpson's *Trigonometry* (1748) while Mollweide published them in 1808. Newton in his *Arithmetica Universalis* gave the formula for $\frac{b+c}{a}$.

We have

$$AZ=AY,\ CX=CY,\ BX=BZ$$

and

$$BX+XC=a=CY+BZ$$

also

$$AZ+AY+CX+CY+BX+BZ=a+b+c.$$

Hence

(1) $$AY=AZ=s-a.$$

Similarly

$$BX=BZ=s-b;\ CX=CY=s-c.$$

Further

$$AZ_1=AY_1,\ CX_1=CY_1,\ BX_1=BZ_1$$

so

$$AZ_1+AY_1=AC+CX_1+AB+BX_1$$

or

(2) $$AZ_1=AY_1=\frac{a+b+c}{2}=s.$$

For CY_1 we have

$$CY_1=AY_1-AC$$

or

$$CY_1=s-b=CX_1.$$

If S denote the area of triangle ABC then
S equals the areas of triangles ABI, ACI, and BCI

or

$$S=\frac{r}{2}(c+b+a)$$

and

(4) $$S=rs.$$

Also S equals the area of triangles ABI' and ACI' minus the area of triangle BCI'

or

$$S=\frac{r'}{2}(c+b-a)$$

whence

$$S=(s-a)r'. \tag{5}$$

The line CI bisects angle C and the line CI' bisects $180°-C$, hence right triangles CIY and $CI'Y_1$ are similar. Therefore

$$\frac{r}{CY}=\frac{CY_1}{r'}$$

or

$$rr'=(s-b)(s-c). \tag{6}$$

Combining equations (4), (5), and (6) we get

$$S^2=s(s-a)(s-b)(s-c) \tag{7}$$

or

$$S=\sqrt{s(s-a)(s-b)(s-c)}. \tag{7'}$$

From equations (4), (5), and (7') we get

$$r=\sqrt{\frac{(s-a)(s-b)(s-c)}{s}}$$

$$r'=\sqrt{\frac{s(s-b)(s-c)}{(s-a)}}. \tag{8}$$

Finally triangles AIB and $AI'C$ are similar for

$$\angle BAI=\angle CAI'=\frac{A}{2}$$

and

$$\angle ABI=\angle AI'C=\frac{B}{2}.$$

Hence

$$\frac{AI}{c}=\frac{b}{AI'}$$

or

$$AI \cdot AI' = bc. \tag{9}$$

The half angle formulas now follow at once. We have

$$\tan\frac{A}{2} = \frac{r}{s-a}, \quad \tan\frac{B}{2} = \frac{r}{s-b}, \quad \tan\frac{C}{2} = \frac{r}{s-c}. \tag{10}$$

Further from triangles AYI and AY_1I' respectively;

$$\sin\frac{A}{2} = \frac{r}{AI} \quad \text{and} \quad \sin\frac{A}{2} = \frac{r'}{AI'}.$$

Multiplying these together gives

$$\sin^2\frac{A}{2} = \frac{rr'}{AI \cdot AI'}$$

which by equations (6) and (9) gives upon extracting the square root

$$\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}. \tag{11}$$

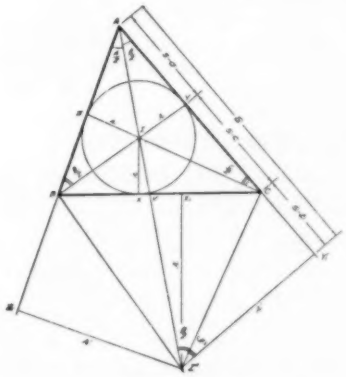


FIG. III

By a similar analysis or by cyclic permutation we get

$$\sin\frac{B}{2} = \sqrt{\frac{(s-a)(s-c)}{ac}};$$

$$\sin\frac{C}{2} = \sqrt{\frac{(s-a)(s-b)}{ab}}.$$

Finally from the same triangles

$$\cos\frac{A}{2}=\frac{AY}{AI}=\frac{s-a}{AI} \quad \text{and} \quad \cos\frac{A}{2}=\frac{AY_1}{AI'}=\frac{s}{AI'}.$$

Multiplying together gives

$$\cos^2\frac{A}{2}=\frac{s(s-a)}{AI\cdot AI'}$$

which by use of equation (9) becomes upon taking the square root;

$$\cos\frac{A}{2}=\sqrt{\frac{s(s-a)}{bc}}. \tag{12}$$

The corresponding formulas are:

$$\cos\frac{B}{2}=\sqrt{\frac{s(s-b)}{ac}}\ ; \quad \cos\frac{C}{2}=\sqrt{\frac{s(s-c)}{ab}}.$$

We may also obtain the formulas for $\sin A/2$ and $\cos A/2$ by computing the length of AI.

From the equations

$$\tan\frac{A}{2}=\frac{r}{s-a} \quad \text{and} \quad \tan\frac{B}{2}=\frac{r}{s-b}$$

we obtain the five part check formula;

$$\frac{\tan\dfrac{A}{2}}{\tan\dfrac{B}{2}}=\frac{s-b}{s-a}=\frac{a+c-b}{b+c-a}. \tag{13}$$

The given angle should be taken as the missing part.

From Fig. I we have that the area of triangle ABC is

$$S=\frac{bc\sin A}{2}. \tag{14}$$

From equation (1)

$$\sin A=\frac{a}{2R}.$$

Multiplying these equations together gives

(15) $$S=\frac{abc}{4R}, \quad \text{or} \quad R=\frac{abc}{4S}.$$

Since

$$S=rs$$

we also have

(16) $$Rr=\frac{abc}{4s}.$$

The derivation of the group of formulas one of which is

$$a^2=b^2+c^2-2bc\cos A \quad \text{has been omitted,}$$

since this derivation is given in almost every trigonometry text. It is from these formulas that the expression for area and the half angle formulas are usually derived by analytic means.

There is one more modern tendency that I should like to protest against. The recent trigonometry texts in many instances present only an absolute minimum amount of material —the bare bones of the subject. No wonder many students find it so dry. The subject needs to be enriched with new interesting material, new theorems and applications.

$1,000 PRIZE OF AMERICAN CHEMICAL SOCIETY GOES TO YOUNG HARVARD PROFESSOR

The $1,000 prize of the American Chemical Society for 1937 has been awarded to Dr. E. Bright Wilson, Jr., assistant professor of chemistry in Harvard University, it is announced here. The award, bestowed annually upon a scientist under thirty-one years of age and of unusual promise, goes to Dr. Wilson, who is twenty-nine, for his experimental work in physical chemistry.

Dr. Wilson was born in Gallatin, Tenn., attended New York City schools and Lawrenceville School, and in 1930 received the degree of Bachelor of Science from Princeton University with highest honors in chemistry.

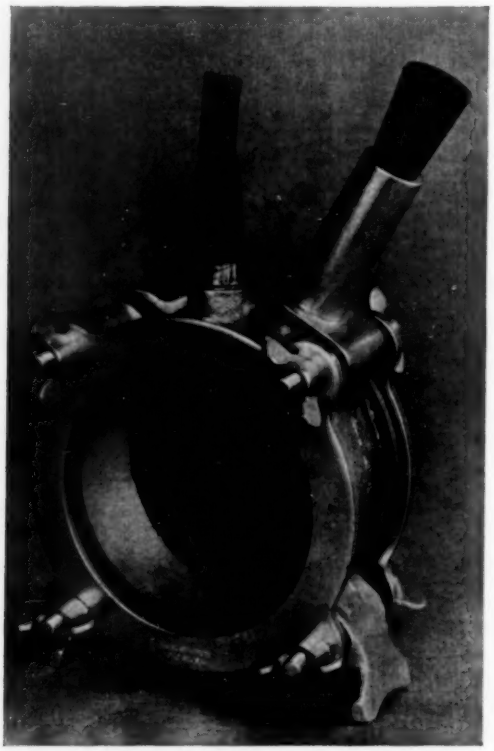
At Princeton he received the degree of Master of Arts in 1931; and at the California Institute of Technology received the degree of Doctor of Philosophy in 1933.

The prize will be formally presented to Dr. Wilson at the ninety-fourth meeting of the Society to be held in Rochester, N. Y., September 6 to 10. Maintained by Dr. A. C. Langmuir of Hastings-on Hudson, N. Y., and his brother, Dr. Irving Langmuir, Nobel prize winner in chemistry, it provides for "recognition of the accomplishment in North America of outstanding research in pure chemistry by a young man or woman, preferably working in a college or university."

AN OSMOSIS DEMONSTRATION APPARATUS*

By S. M. Troxel
State Teachers College, Trenton, New Jersey

The preparation of an osmosis demonstration commonly requires a relatively large expenditure of time on the part of the instructor. Then, in many cases, the demonstration is set up in such a manner that many of the students cannot observe all



Osmosis demonstration apparatus.

parts of the apparatus from their customary positions in the classroom. Also, in many demonstrations, osmotic action takes place so slowly that the demonstration is not complete within a single class period. The apparatus pictured and described here was designed because none of the osmosis demonstrations known to the writer was entirely free from these objectionable features.

* This osmometer is available through the Central Scientific Company.

The central portion of the apparatus illustrated consists of a white metal casting. Into the top of this casting is sweated a metal tube to which a glass manometer tube may be attached with rubber tubing. Another tube, for filling and emptying the osmometer, is sweated in near the top of the casting. At the bottom are the legs, cast integrally with this central part.

Each side of the central casting is covered with a semi-permeable membrane, held in place by a metal ring which is fastened by studs and wing-nuts. The studs are permanently secured in the central casting. A rubber gasket, placed between the membrane and the outside ring, is used on each side in order to obtain a leak-proof fit. The apparatus as pictured is equipped with ordinary Cellophane (not moisture-proof), which is, of course, transparent. The effective diameter of each membrane is about 6 cm.

When the osmometer is originally set up, it is necessary to soak the membranes to be used in water and fasten them in place. The solution to be used in the osmometer is introduced through the tube provided for that purpose, the manometer tube is attached and the osmometer is placed in a battery jar or large beaker of water. The apparatus is more easily observed if a rectangular battery jar is used. The water commonly softens the membranes, allowing them to stretch somewhat, and if it is desired to demonstrate osmosis soon, more solution should be added to the osmometer, bringing the liquid level up into the manometer tube. To secure optimum visibility of the liquid in the manometer tube, the liquid should be colored and the tube should be backed with a white card or scale.

Of the large number of materials available for use as membranes, Cellophane and artificial parchments have been tried. With a number of solutions, Cellophane gave osmotic action about 70% more rapid than the parchments tried. Cellophane has the advantage, for demonstrations, of transparency, but probably some artificial parchments possess greater durability and strength. The strength of the Cellophane has been found sufficient to withstand the pressure of a column of potassium carbonate solution of specific gravity 1.6, 150 cm. high. A few tests on the bursting strength of Cellophane membranes in the osmometer indicate that this is probably about the maximum pressure that the particular thickness of Cellophane used will withstand.

A very thick molasses, glycerol, 55% potassium carbonate solution and saturated calcium chloride solution have been tried in the osmometer. Glycerol gives more rapid osmosis than molasses, and in addition is more easily rinsed from the osmometer. Failure to wash all the glycerol from the apparatus is undoubtedly beneficial rather than harmful, because of its hygroscopicity and its plasticizing action on cellulose. While the concentrated salt solutions named above give more rapid osmosis than glycerol, it is felt that this plasticizing more than outweighs the advantage of speed, particularly since the action with glycerol is sufficiently rapid. The useful life of the membranes may be further conserved by storage in the dark.

Using Cellophane for membrane material and a manometer tube of 3 mm. inside diameter, glycerol gives osmosis at a rate which produces a rise in the manometer tube of about 1.6 cm. per minute. With heavy molasses, the rate is about three-fourths as rapid. With 55% potassium carbonate solution and with saturated calcium chloride, rises of about 2.3 cm. per minute have been observed. From the above data, it can be seen that glycerol with a manometer tube of 5 mm. inside diameter will give a rise of approximately 1 cm. every two minutes, which is a satisfactory rate for demonstrations.

The membranes, once installed, form a more or less permanent part of the apparatus, and can be left in place until they become broken. If used as suggested above, and for only occasional demonstrations, they may be expected to last for at least a few years. Consequently, preparing an osmosis demonstration involves only filling and setting up the osmometer, allowing a short time for the membranes to become equilibrated with the liquids being used. Osmosis may be stopped by taking the osmometer from its battery jar of water, and it may be again initiated by replacing the apparatus in water. This procedure is convenient if one desires to demonstrate the phenomenon to different classes over a period of from a few hours to several days.

Demonstrations with the apparatus may be made effective for two reasons. First, the osmotic action and all parts of the apparatus can be observed directly by an entire class. In the second place, the osmotic action is sufficiently rapid to be observable during even the briefest discussion of osmosis—it is unnecessary to wait until the next day or the end of the class period to complete the demonstration.

THE STORY OF NATURE STUDY AT SYRACUSE

By William Gould Vinal
National Recreation Association

The story of Nature Study in any locality may be compared to the weaving of cloth. There are many threads that go to make the finished fabric. The warp and woof is determined not only by the natural advantages but the early settlers and the cultures that they may bring. Many movements are due to the interests and possibly the whims of individuals. Every community has its naturalists, many of whom have reached national stature. It is only by placing these local stories side by side that we are enabled to make generalizations. Such names as Agassiz and Audubon appear in the annals of nearly every early American city. And then there is the question of what does nature study include. The readers of this article may be surprised to read about *Hiawatha* and *David Harum* as nature classics. Class discussions on this as well as other suggestions may be profitable. Syracuse is but sixty miles from Rochester and yet how different is the story of Nature Education in the two cities. Each thread of the story is taken up separately.

I. THE GLACIER MADE ONONDAGA SCENERY

He who would understand as he tours must have a smattering of physiography. The glacier made the scenery of the Onondaga country. The Onondaga valley, a southern gateway to the Appalachian Plateau, was ploughed by a tongue of the glacier which left hanging valleys with waterfalls. The rock floor was buried under a hundred feet or more of drift. The terminal moraine deposited as the Ice King tarried at Tully rises 1600 feet higher in twelve miles. The "Drumlins" are gravel hills with their long axes running S E which indicate the direction in which the ice mass was pushed. The lakes occupy depressions left by the glacier. The more shallow depressions have filled with a jet black residue of vegetation and are known as the "Great Levels" or "black bottoms." The rock gorges with their step falls are post-glacial. Each glacial item is a geological alphabet out of which has been written the story of Syracuse.

II. THE ONONDAGAS HELD THE FIRST LEAGUE OF NATIONS

The first people in the region were the Indians. Onondaga means the "men of the mountains." *The Song of Hiawatha*

(1855) was located on Onondaga Lake.[1] Hiawatha's grandmother, old Nokomis, taught him all the lore of the woods and streams. He

"Learned of every bird its language,
How the beavers build their lodges."

The old warrior Iagoo "fashioned for him a bow and arrows." He realized the foolishness of wanton slaughter. Can you picture the

"Murmuring pines and the hemlocks"?

The gathering of canoes on the shores of Onondaga? The silhouettes of half-naked Indian warriors about the camp fire smoking the pipe of peace? Hiawatha said: "Become a united people." Can you step back three hundred years to the first League of Nations? The famous Iroquois League was held in the Onondaga Long House. The events were orally transmitted from generation to generation. Joshua V. H. Clark obtained the story from two Onondaga chiefs. It appeared in the New York *Commercial Advertiser*. Henry R. Schoolcraft, Indian Agent for the Department of the Interior, used Clark's notes as the basis for tales to illustrate Indian character and history.[2] The tradition of this Congress of Peace[3] pictures Hiawatha coming to earth to relieve human distress. The song tells of his departure to the Great Spirit. Thus Henry Wadsworth Longfellow (1807–1882) immortalizes in verse the mythical hero "Hiawatha."

Not all of the story of the red man is traditional. Some of it is based on artifacts or stone implements. Harpoon heads made from walrus tusks suggest an early Eskimo influence. This was first recognized by Beauchamp. The Mound Builders were Indians who used copper implements and also materials from Flint Ridge in Ohio. The Algonkians appeared after the Mound Builders with their grooved axes and distinctive pipes and pottery. The Iroquois were agricultural. They raised tobacco and corn. Their long houses were not the hogan (mud hut) of the western Indians but were made of elm bark.

The unearthing of cultures and even the arranging of these nature events has been a long process. It suggests a process of

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[1] Rev. William M. Beauchamp. *Journal of American Folk Lore*, 1891.

[2] Henry R. Schoolcraft. *Notes on the Iroquois* 1847.

[3] The United States Government concluded a treaty with the Six Nations in 1788 and acquired lands known as the "Military Tract."

thinking which may be presented as a game. An electric desk lamp may have suggestions of a kerosene lamp and of a candle. The discovery of fire, the wick, and glass had to precede the electric bulb. The tungsten filament followed the carbon filament. The following events are arranged alphabetically but not chronologically. Number the sixteen items in the order in which they must have occurred in Syracuse. The reader may wish to finish this story before undertaking the game.

Apple Orchards	Onondaga Hills
Botany	Onondaga Lake
Buffalo	Physiography
Coal	Salt Beds
Drumlins	Salt Pork
Education	State Parks
Flint Arrows	Three R's
Nature Recreation	Tin Cans

The Onondaga Indians had a picturesque language. The wild crab apple was called the "real apple" which meant the original apple.[4] From Pursh's *Journal*[5] I have selected twelve plants which are arranged alphabetically. The translations of the Indian names are not arranged in order. The game is to number the Indian interpretations so that thay will correspond with the English. For example: Yellow root describes the carrot and should be marked 4.

English Name		*Onondagan Interpretations*
1. Aspen	____	Whiskered
2. Balsam	____	Kittens
3. Barley	____	Indian Cradle
4. Carrot	____	Chicken's Fingers
5. Catkins	____	It Opens the Swamps
6. Catnip	____	Noisy Leaf
7. Cowslip	____	He Looks at Me
8. Jack-in-the-pulpit	____	Birch Smelling Plant
9. Pansy	____	Blisters
10. Samphire	____	Tail at the End
11. Timothy	____	Cat Eating Leaf
12. Wintergreen	____	Yellow Root

The Onondagan Festivals were "botanical" in origin. They were the plantin, the strawberry, the green bean, the green

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[4] The cultivated apple was introduced from Eurasia. William Blackstone (1595–1675) planted and cultivated apple orchards in Rhode Island in about 1634.

[5] Frederick Pursh, *Journal of a Botanical Excursion in the Northeastern Parts of the States of Pennsylvania and New York during the year 1807*. Edited by William M. Beauchamp, Syracuse, for the Onondaga Historical Association. 1923.

corn, the harvest and the maple sugar festivals. Many of these festivals have come down to the white man. Perhaps it was the botanist rather than the geologist or zoologist that linked the nature lore of the Onondagans with the natural history of the early settlers.

III. ONONDAGA ATTRACTS EARLY BOTANICAL EXPLORERS

John Bartram (1699–1777), the first native American botanist, from his earliest days on the farm had a passion for plants. He had more interest in living plants than in an herbarium. His Botanic Garden (1728) was three miles out of Philadelphia. Benjamin Franklin and George Washington often visited Bartram. His garden is the oldest shrine for American Botanists. Linnæus called him "the greatest botanist in the world." It was while on a collecting expedition for his Botanic Garden that Bartram came to Onondaga.[6]

Bartram sent an Indian to Onondaga with a string of wampum to announce his coming. His diary contains much of interest. July 21st—"We kept along the side of a hill . . . the soil good, timber tall, and abundance of ginseng; here the musquetoes were very troublesome . . . some large pines growing upon it . . . We descended . . . over good land producing sugar maples, many of which the Indians had tapped to make sugar of the sap . . . generally a moderate descent into the fine vale where this capital (if I may so call it) is situated." Bartram and his party were given a cabin 80′ long, 17′ broad and with a passage 6′ wide. On each side were apartments 5′ wide on which were large pieces of bark and on which on "extraordinary occasions spread mats of rushes, this favor we had; and on these floors they set or lye down every one as he will. . . . All the sides and roof of the cabin is made of bark, bound fast to poles set in the ground, and bent round on the top. 23rd. We hired a guide to go to the salt springs 4–5 miles off." The Indians dig holes, dip kettles in the brine and boil contents to get salt. The first writers, the Jesuits (1657), noticed that the Indians did not use salt. By the time Bartram arrived (1743) the red skins had evidently cultivated a taste for it.

Peter Kalm (1716–1779), a friend of Linnæus, came to America in 1748. He was another botanist who visited the Iroquois Country. He came a few years after Bartram and likewise kept

[6] "Observations on the Inhabitants," etc., made by Mr. John Bartram in *His Travels from Pensilvania to Onondaga, Oswego and Lake Ontario, in 1743.* This diary was published in London, 1751.

a diary. He said that "Squashes are a kind of gourds which the Europeans got from the Indians." Kalmia was named for him.

Ephraim Webster (1754–1826), the first white settler, made his camp in 1786. As a trapper, fur trader, fisherman, and pioneer he was by necessity a naturalist. At the age of fourteen he was a scout in the Revolution (1776). Unwittingly he founded the city of Syracuse. He came, when the country was in a state of nature, via the Mohawk to Onondaga Lake and thence by batteaux up the creek to settle at the Hollow. He engaged in ginseng trade with the five nations and was considered honest, industrious and brave.

Francis Adrian Vanderkemp visited the locality in 1792. He described the fresh creek lobster as superior to the sea lobster and the "eel of the Oneyda Lake is equal to the best of the Holland market. . . . We took a catfish of four span and a half."

Frederick Pursh (1774–1820) came to America in 1799 and to Onondaga in 1807. He carried on botanical explorations for twelve years. He writes: "I was informed that a strange tree, with leaves as big as a horse, grew 'over in the Diggins' . . . This find proved to be Hercules' Club; Aralia spinosa." Beauchamp says that this plant was introduced in 1848 and escaped from cultivation. On July 20 Pursh found the Hart's Tongue fern which grows in very few stations in the United States.

John Goldie was here in 1819. He reported the aspidium goldieanum.

IV. EARLY ONONDAGA INDUSTRIES ARE DEPENDENT ON NATURAL RESOURCES

Things don't just happen. For every event there is a cause. The chain of events in the history of Syracuse are the result of many causes. In spite of the classical name Syracuse the city has a nature background. The 80 feet of Niagara limestone (Silurian) put down in Marine days was to contribute building stones. The sandstone topping the highest hills (Devonian) was to be used for whet stones. The "oak lands" (oak-hickory climax forests) were to give way to wheat and the beech-maple forests were to give way to grazing. The white pines described by Bartram were soon reduced to stumps. Even the hemlock was nearly swept away. The alluvium was to see notorious mud roads—almost impassable until the plank roads (1844) which were to collect tolls. The Cicero Swamp and other "Great

Levels" were to lose their dense growth of balsam and tamarack for celery, onions, and the sugar beet. The Onondagans made baskets out of ash splints. The Austrian settlers were to make Liverpool the center of the basket willow trade. By 1819 salt was to be money. The story of the development and use of any one of these local products of nature is a romance. Time and space permit the relating of only a few.

Father Simon Le Moyne, Jesuit Missionary to the Onondagas, discovered the first salt springs (August 16, 1654) and boiled salt that day. The Indians did not dare to taste it, believing it to be inhabited by a demon. Onondaga Springs were the first known source of salt in the United States away from the sea coast. In 1788 the Onondagas ceded to the state all lands "except the salt lake and the lands for one mile around the same." The salt springs were purchased from the Indians by treaties (1795). "Salt Point" or Salina was low and marshy and a source of miasmatic diseases. Most of the early settlers were soldiers from Connecticut. These early squatters had considerable contention as to "prior rights." The State of New York finally created the office of Salt Superintendent (1797).

Salt boiling was done in long buildings. Wood was used for fuel and later coal (1849). The men scooped the salt into coarse bushel baskets. Solar evaporation began in 1822. (It was introduced by Cape Codders who were well versed in the art.) The brine was carried in wooden pipes (made from sour gum, tupelo, or pepperidge) to shallow vats which had covers on wheels. If rain threatened a bell was rung and men, women, and children ran from adjoining cottages to "shove the covers." The "Salt Pointers" bartered salt for farm produce which could only be brought over in the winter when the marsh was frozen. In 1817 four bushels of salt was worth one bushel of corn, and to obtain 100 lbs. of flour it was necessary to exchange twelve bushels of salt.

The salt wells sunk in Onondaga varied from 600 to 1969 feet in depth.[7] At one time there were 50 wells. At the peak of the industry (about 1862) there were 75 miles of pipe line and about 9 million bushels of salt were obtained. In 1797 there were 25,474 bushels produced and in 1828 there were over a million bushels. The state received in taxes on all Onondaga salt about 10 million dollars. Over half of the Erie Canal[8] was built by the Syracuse salt tax.

[7] Annual Report of the Superintendent of Onondaga Salt Springs for the year 1884.

[8] Erie Canal was kept open in Syracuse until 1923.

The first school of Syracuse (1797) was kept by Captain William Connor in a salt block in Salina. He enlisted in 1775 when he was seventeen years old. At the age of 40 he was a salt boiler and teacher.

Ten years ago the writer—as teacher of nature education in the New York State College of Forestry—took a class on a field trip to Salina and Liverpool. The students had dip nets and followed the tow path of the Oswego Canal collecting water insects and other fresh water material. The ruins of the old salt covers and a lone chimney were viewed.

Imagine my surprise in 1936 to be driven along a boulevard which was once the canal and of seeing a "Salt Museum" in a large building restored with the chimney. The drive has been landscaped and the springs have been put in order. The following was copied from a marker: "The Gale Salt Spring. Thomas Gale, the largest manufacturer of Solar Salt in this country, once had a salt storehouse over this spring. The business was carried on by his son, Thomas K. Gale, who was the last to manufacture salt from the brine of the Onondaga Salt Springs in 1926." The depth was given as 90 feet through original wooden casings.

Around the spring is growing a patch of the slender glasswort or samphire. I recall a trip that I once made to Syracuse from a meeting of the American Association for the Advancement of Science in Atlantic City. The salt marshes near the coast were "afire" with this plant. When I looked out of the Pullman window in Syracuse the next morning I was greeted with a repetition of the scene. This was made possible by the brine pumped up from the Salina formation. I wondered which place saw samphire first and how it crossed the Applachian Plateau or was it once universal and now reduced to patches stranded on these "islands." The answer would make an interesting chapter in plant ecology.

The next largest business to salt was the cooperage industry. Barrel making was first from white oak staves and later from pine and hemlock. Barrels used wood, evaporation took wood, and the wood-burning locomotives took more wood. That did not apparently make much difference as the forests must be cleared for agriculture and grazing. Besides it looked as though there was wood enough for all time. The wheat crop moved west but grass and alfalfa remained and made dairying possible. In 1845 a Connecticut Yankee started tobacco as a commercial

crop and by 1870 there were over a million pounds produced in Onondaga County.

Ginseng was discovered in America (1716) by Father Jartoux, a Jesuit Missionary. Bartram reported it as growing abundantly in Onondaga (1743). The roots are prized by the Chinese as a panacea for all ills. The root is supposed to cure the part that it resembles. Ginseng was collected commercially as early as 1757. George Stanton, while recuperating from sickness by strolling through the forest, conceived the idea that the supply might become exhausted and that it might be cultivated. Stanton was a pioneer ginseng grower in America. It soon became an Onondaga industry.

The whetstone industry was made possible by the fine grade of sand stone to be found on the Onondaga hills. The Labrador Oilstone Company of Manlius (1878) cut 90 tons the first year. The Labrador stone is a harder, coarser stone used for kitchen purposes. It was cut by strips of iron which were supplied with sand and water as the iron bands move backward and forward against the rock. The sawing sand was obtained from Sylvan Beach, near Oneida Lake. By 1898 over 500 tons of whetstone were cut.

V. THE AGE OF ONONDAGA HOAXES

There was an age when natural history hoaxes found a more fertile ground on which to thrive. Even today there are enough gullible people to make the release of a sea serpent good reading in a newspaper or to make cure-all medicines a profitable business. With the spread of scientific thinking in the elementary grades humbugging is less apt to gain a wholesale headway.

The *Pompey Stone* was found in about 1820 on a farm. On it were carved a tree, a snake, 1520, and other lines. The truth was exposed about 74 years afterwards.

The *Cardiff Giant* was dug up on the farm of "Stub" Newell in Lafayette, October 16, 1869. George Hall had a stone cutter make the giant out of a block of gypsum. It was 10 feet long and weighed 2996 pounds. It was brought by rail from Chicago. P. T. Barnum offered $60,000 for it.

In 1885 Thomas H. Bex, a taxidermist placed a seal in the Erie Canal.

The *Botanic Infirmary* of Dr. Cyrus Thomson was a three story brick building located in Geddes on the old turnpike. In front there were 10 large Ionic stone columns from Vermont. These were the first stones to be imported. It is said that an

old Vermonter when inebriated would embrace these columns with warm affection saying that he too came from the Green Mountains.

As early as 1825 Samuel Thomson wrote in his book: "Our life depends on heat; food is the fuel that kindles and continues that heat; heat I found was life, and cold was death, and that all constitutions are alike." Cyrus, the son of Samuel, usually prescribed "Hot drops No. 6," a concoction of lobelia, whiskey, and cayenne pepper. He was careful to prescribe to patients who were likely to recover. The building was covered with signs. One read: "The Lord has caused medicines to grow out of the earth and why should man despise them?" Propaganda was spread through pamphlets such as "Learned Quackery Exposed" (1844). He held that vegetable remedies were planted by the God of Nature and that mineral poisons hurry thousands to untimely graves. Thus the Thomsonian system was described to open the eyes of the devout and the ailing against the poisons of the apothecary shop—arsenic, opium, physic, blisters, and lance. A song included in the pamphlet ran as follows:

> "The nests of College birds are three
> Law, Physic and Divinity;
> And while these three remain combined,
> They keep the world oppressed and blind."

Whether to put the *Syracuse Museum* (1835–1859) into the "hoax class" or the "scientific class" is a moot question. Perhaps it more truly represents a period of transition. It dealt in horrors and had curiosities such as the embalmed head of a New Zealand Chief which was handsomely (?) tattooed. A stuffed crocodile was smashed during a fire and was discovered to be made of wood and leather. Then there were life-sized wax figures, cases of live snakes, and the Phantasmagoria (magic lantern). The aim was commercial amusement rather than recreational or educational science.

VI. THE AGE OF SPECIES HUNTING AND INFORMATION GATHERING

The Syracuse Botanical Club (1878) was an outgrowth of trips and lectures held under the leadership of Rev. Samuel R. Calthrop. Mrs. Stiles M. Rust was first president. Mrs. L. Leonora Goodrich (1831–1923), 30 years a teacher in the city schools, was president for about 40 years (1884–1923). The club obtained an excellent herbarium through weekly excursions.

Mrs. Goodrich compiled, classified, and catalogued the collection which appeared under the title of *Flora of Onondaga County* (1912). Mrs. Goodrich was a student in Amelia Bradbury's Seminary and like Miss Bradbury was a member of Dr. Calthrop's Congregation.

Rev. William Martin Beauchamp (1830–1925) was perhaps more widely known as author and scientist than as a divine. His *Land and Fresh Water Shells of Onondaga County* (1886) is a standard reference for local conchologists. He writes: "I have searched the country from the highest hilltops, over 2000 feet above the sea, to the bottom of many waters, and give the present results of my knowledge." His paper was the result of ten years' work. His suggestion of using hot water to "extract the animal" is characteristic of the times in that investigators did not stop to consider that the shell is a part of the animal. He further recommends "spring and fall are the best seasons for collecting most shells, as fewer immature specimens then occur." There are still a few shell collectors who find the skeleton more interesting than the soft parts that make the shells or the life history which tells about the development of the animal.

Beauchamp was the successor of Lewis Morgan as the authority on the Iroquois. His *Iroquois Trail* was published in 1892 and the *History of New York Iroquois* appeared in 1905. In 1904 he was adopted into the Onondagas and was awarded an Indian name meaning "Beautiful Rainbow." Known as a "grand old man" he typifies industry and accomplishment. His interests were many, wide and useful.

Perhaps Beauchamp's attitude was best summed up in his inaugural address to the Academy of Science (March 15, 1901) when he said: "I am no profound scientist; perhaps more a forager than a cultivator, but I have greatly enjoyed much desultory work." Beauchamp was a fellow of the American Association for the Advancement of Science. Upon his death he left an unfinished book on the life of John Bartram.

Morgan K. Barnum published a Bulletin under the title, *List of the Birds of Onondaga County* (1886) as a bulletin of the Biological Laboratory of Syracuse University. Nettie M. Sadler who taught biology at Central High School had printed *A Hundred Birds of Syracuse* which has been revised and by October, 1917 it included 174 species. Beauchamp also kept bird records and noted a White Egret, Baldwinsville, 1896;

White Pelican, Onondaga Lake, 1893, and a Swan, Oneida Lake, 1886.

Doctor H. D. House, State Botanist, was a native of Oneida and a graduate of Syracuse (1902).

VII. NATURE STUDY IN THE SCHOOLS

Perhaps the first teacher in Syracuse to introduce the natural sciences to any degree was *Amelia Bradbury* (1797–1850). In about 1840 Miss Bradbury opened a "Seminary for Young Ladies." Many of the first families of the village were to be found on the register of the school.

Edward A. Sheldon (1823–1897) was born at Perry Centre, New York. His early education was home training on the farm and a common school. He entered Hamilton College at twenty-one but had to leave on account of his health. For several months he lived outdoors with well-known horticulturists of Newburgh, New York. He provided a free school for children of the poor in Oswego which was called the "Ragged School" (1848). He became its teacher and soon after was the appointed Superintendent of Schools in Syracuse (1851–1853). On his return to Oswego in 1853, he established arithmetic schools for boys employed on the lakes in the summer. He asked for trained teachers to carry on object teaching which he saw at "London Home and Training School" in Toronto. He was given consent with the understanding that it should be without cost to the city. Sheldon organized the first city training school in the United States (1863). Many people opposed the undertaking but the work was vindicated by a committee of which Prof. Green of Brown University was Chairman (1865). He resigned his superintendency to become Principal of the Oswego Normal School (1866) which was to become the national center of object teaching and Pestalozzlian principles. Opposition to these "new fangled ideas" undermined his health but he returned to the work again in 1881. Sheldon will be remembered for his faith and hope for the future of progressive educational methods.

Anne Marie Treadwell Redfield was born in Canada (1800–1888), educated in Vermont and later resided in Syracuse. Her book *Zoological Science or Nature in Living Forms* (1858) was dedicated "To Teachers, to Parents and Heads of Families, to all who are lovers of Natural History and desire its advancement." Louis Agassiz said, "It would do credit to the majority of college professors in this department." Two copies of this

book are stored in the archives of the Syracuse Public Library. In the preface the work is prepared "As an accompaniment to the 'General View of the Animal Kingdom'—a chart. . . . The possessor of the chart might have recourse to works of two kinds—one purely scientific, like those of Cuvier and others, or the works on Natural History published by the State Authority; the other, of a strictly popular character, in which not a single scientific or technical term is employed. . . . The present volume, being sort of medium between the two." There is a large school of nature teachers today who feel that the subject can be both popular and scientific at the same time. It is also interesting to know that Mrs. Redfield added questions to each section for teachers. None of the questions which follow would be considered scientific today. Who is placed at the head of the Animal Kingdom? How is he allied to animals? How to spiritual beings? In what respect does he surpass all other created beings?

Walter A. Brownell (1838–1906), Principal of Syracuse High School (1871) and Professor of Chemistry and Geology (1872) during summer vacations was Professor of Geology and Mineralogy in the School for Teachers at Martha's Vineyard (1881–1886). He obtained his Ph.D. from Hamilton in 1876. Dr. Brownell believed in practical knowledge and when a pupil attempted to use exact words of the textbook he would ask if they associated with parrots.

In the beginning of the twentieth century Minnie L. Overacker, Chairman,[9] speaks of the Course in Botany as being in a transition state from textbook recitation and analysis of flowering plants to textbook recitation and a reasonable amount of laboratory work. In the notebooks appeared drawings and records of experiments. A study of seeds and germination and of microscopic structures was a part of the program. To throw off the yoke of a textbook, to experience and enjoy nature was to take another half century. Freedom with the gifts of nature has been as painfully slow as religious liberty for those brought up in the old-fashioned New England way, "in the fear and administration of the Lord." Nature recreation is an oportunity and not an obligation. On the other hand, of course, one needs to be shown the possibilities.

[9] Fifty-third Annual Report of Board of Education in City of Syracuse for year ending July 31, 1901.

VIII. NATURE LORE IN ONONDAGA

Longfellow, Westcott, and Calthrop have shown not only to Syracusans but to the world that nature is more than cold facts. "David Harum"[10] was an honest, humor-loving country man. David Harum ranks with Hiawatha as an immortal nature-hero of fiction. *Edward Noyes Westcott* (1847–1898) set the story in the Erie Canal country in the village of Homer. Due to tuberculosis Westcott gave up his work as a Syracuse bank cashier (1896). He went to the Adirondacks for his health and wrote the book during his illness. The manuscript was returned by seven publishers. He never saw his book in print and never lived to see the sales which mounted to well over the million mark. The story was dramatized in 1900 and recently made a sensational hit on the screen with that genial cowboy, Will Rogers, playing the leading part.

David Harum might sit near the stove of any country hotel. The reader may select his own. The writer is reminded of the old Burden Inn on the Cherry Valley Turnpike at Morrisville with its Currier and Ives pictures of Nancy Hanks and other horse celebrities of the gay nineties. David Harum's experience as a boy at the circus or his nature philosophy has as much universal appeal as Kipling's *Jungle Stories*. We will let David Harum repeat some of his own creations. They rank well as rules of pedagogy for progressive nature teachers.

"Ev'ry horse c'n do a thing better'n' spryer if he's ben broke to it as a colt."

"Some hosses will balk with some folks, an' not with others."

"Was it a horse?" asked Mrs. Bixbee, referring to the animal the deacon had worked off on David. "'Wa-al,' David replied, 'mebbe it had been some time, but at the partic'lar time the only thing to determine that fact was that it wa'n't nothing else.' "

"Do unto the other feller the way he'd like to do unto you, an' do it fust."

"Wa-al, a reasonable amount of fleas is good for a dog: Keeps him from brooding on bein' a dog."

Dr. Samuel Robert Calthrop (1829–1917) came to America in 1850 and to Syracuse as assistant to Rev. Samuel May in 1868. Like Dr. May he was an abolitionist and could look both science and religion straight in the face. He enjoyed the miracles

[10] Westcott, Edwards Noyes. *David Harum*. Appleton, 1898.

of his garden on Primrose Hill. As a boy he showed honesty and fearlessness when he refused to graduate from Trinity College because to do so he must sign the 39 articles of the Church of England. He taught Alexander Agassiz to play cricket, and trained the crews of Harvard, Yale, Cornell and Syracuse. He was the soul of the Syracuse Boys Club. He found time for attainment in astronomy and was given a telescope by his congregation. He discovered weather forecasts based on sun spots and formulated a law. He lectured weekly on astronomy at Miss Mary Jackson's boarding school (Keble School). In the spring he would take a number of his congregation on a field trip to study botany and geology.

But Dr. Calthrop was more than a scientist. In his Harvard days he had come under the influence of Emerson. He was an interpreter of science. He was a lover of nature and for over 40 years as pastor of May Memorial he drew apt illustrations for his sermons from Nature's book.

"I sat and saw that all nature was obedient to Law. . . . I stooped down and picked up the petrified mud of the old sea-bottom and stood in thought on the shore of that primeval sea whose waters saw the first dawning of life upon the planet . . . Lawless immortals! Running, dashing, hither and thither, bound seemingly by no law save their own wanton wills!"

IX. TRAINING FOR OUTDOOR LEADERSHIP

The training for outdoor leadership requires as much technique and skill as for the school room. For Syracusans this can best be done at the New York State College of Forestry (1911) and in other departments of Syracuse University. The history of Natural Science at the University is a paper in itself and will not be attempted in this sketch. It was customary for the presidents of the Onondaga Academy of Science (1896) to give an Inaugural address. The following is taken from the Inaugural address of Dr. Charles W. Hargitt (January, 1899), and shows that he recognized nature study as a part of the work of society.

"To know nature as it is, is to be scientific. . . . Huxley has defined science as applied 'common sense.' But common sense is *natural* sense. . . . We hear much nowadays about 'Nature Study.' And if nature becomes transformed under the busy hand of man, and is crowded from our life and thought, then we may foster its return in measure through gardens and parks."

X. OUTDOOR SCHOOLROOMS IN ONONDAGA

Syracuse—compared with Rochester and Buffalo—has lagged in its park offerings. The City Park System (1917) goes back to the "Village Greens." Fayette Park was named in honor of La Fayette who returned to America in 1825. In 1849 an ordinance stopped the beating of carpets on the grass in Fayette Park and also the pasturing of cows and horses. The East Genesee Turnpike formerly ran through it but was made to "go around" when it became a park.

When Syracuse was a "corners" Forman Park was a cedar swamp crossed by a corduroy road. In 1834 it was Forman Square and on January 16, 1839 it was declared a Public Park. Trees were planted there in 1858. The monument to Redfield and Forman was unveiled in 1908. Up to 1934 it was a loafing place for human derelicts. How early a city ceases to make a cow pasture or a bums retreat out of its parks depends on how timely and progressive that city is.

Thornden Park is serving the city on a much higher plane. The property was once owned by Major Alexander H. Davis (1839–1910) who planted the grove, which is one of the features of Thornden. In the grove there is a weeping beech. In by-gone days its smooth trunk invited initials and hearts which necessitated the building of a fence around it. The park's greatest esthetic influence is the Dr. Edmund M. Mills Rose Garden. Dr. Mills was the "Father of Rose Culture" in Central New York. He organized the Syracuse Rose Society (1909) and was president for 15 years until he was elevated to the presidency of the American Rose Society (1924). As has already been noted —the influence of parks may differ. Thornden Park teaches that nature may be a place of culture and beauty. It is a great advance over the park that might just as well be a vacant lot with emphasis on the vacant.

The future is promising. In the past 5 years the Park Department of the City of Syracuse has doubled its maintenance area. At Burnett Park, which is the largest (132 acres), a wild flower garden is planned and a rhododendron—azalea—mountain laurel thicket will be put in at Thornden. In cooperation with the College of Forestry a pinetum will also be an attraction at Thornden. Elmwood is being planned as a nature sanctuary where flowers and trees will be left in their native state. The State Conservation Department is cooperating in having trout and wild animals. There is a 10 acre George Washington Mem-

orial Forest at Burnett Park. The city does not purchase zoo animals. At present they are obtained through the generosity of Peter Kalfelz. This equipment is being furnished by the Park Department. Its use must come through the Recreation Department.

The Clark Reservation of the State of New York at Green Lake, Jamesville (1915) is a supreme example of what a park should be. Mrs. Mary Clark Thompson, Canandaigua, daughter of former Governor Myron H. Clark, was the donor. This park is a noteworthy example of the preservation of a "natural monument" for the lessons it teaches. To preserve such areas someone has to arouse public concern. When it passes to the custody of the people it becomes a public trust which means responsibility and education.

Why was it of public concern that this area be protected against the invasion of the limestone industries? First of all it is due to the true nature of the locality which was unravelled by the successive patient study of Dr. G. K. Gilbert of the U. S. Geological Survey, Professor E. C. Quereau of Syracuse University, and Professor H. L. Fairchild of Rochester University. Green Lake was not formed by volcanic action as once was popularly supposed. When the Niagara frontier was covered by the glacier Onondaga Creek could not flow north but found outlet to the east through the Mohawk Valley—at one time through Jamesville and later through Fayetteville. At each of these areas the water poured over limestone cliffs as at the Niagara Horeshoe Falls. The present rock walls of the amphitheatre show that this "Fossil Niagara" was nearly 200 feet high—on a larger scale than the more noted falls. If the present Niagara should go dry a plunge-basin lake would result without inlet or outlet. Green Lake was formed that way. When the glacier melted far enough north Onondaga Creek again reached the Atlantic via the St. Lawrence instead of through the Hudson River.

The Clark Reservation is a mecca for the botanist as well as the geologist. Pursh reported the Hart's Tongue Fern (1807). This fern is common in Europe but is rare in America and there was some doubt held by botanists as to whether Pursh really found it. Seventy-three years later Pursh was vindicated when the Syracuse Botanical Club rediscovered it in Geddes Gorge (1880) at the request for a search by Honorable George Geddes. Shortly after that it was found in Jamesville. William Cooper

had found it at Chittenango Falls in 1857. The American Fern Society on a field trip (July 14, 1915) discovered 35 species of ferns growing in the tract. The state botanist says that there are over 40 species of ferns there. Cliff brakes, the walking leaf fern, and the Goldie fern are some of the other interesting species found there. The "Selkirk Violet" is a rare variety and both the striped and mountain maple are trees that one would expect to find in the Adirondacks but not in Syracuse. Some visitors may ask why the lake is green when the sky is blue. Why is the lake green and a glass of the lake water colorless? Scientists believe that the color is due to algae plus the reflection of the sky.

The Clark Reservation is Syracuse's Watkins Glen except that Green Lake was made during the Glacial Age and Watkins Glen was made after the Glacial Age. Whether they are kept in their natural scenic beauty or made into the Coney Islands of Central New York depends ultimately on the citizens of the Empire State. Whether they are amusement parks or whether they are used to teach great lessons of nature must also be decided. Some day the State Parks will afford Ranger Naturalists on the same order as the National Parks. When that time comes the visitors to these parks will be assured of field excursions which will be both instructive and inspiring. Syracuse has outdoor schoolrooms. The city should be more concerned about making a profitable use of these educational areas. Green Lake didn't just happen. The Clark Reservation didn't just happen. Likewise a Syracuse Nature Program will not just happen. There must be enough people who care enough to have it.

FORTY-SECOND ANNUAL CONVENTION

The 42nd annual convention of the Department of Science Instruction of the NEA will be held at the Masonic Temple, Detroit, Mich., from June 28 to July 1, 1937. Reservations for hotel accommodations should be made through the NEA Housing Committee, 1805 Stroh Building, Detroit. Convention Headquarters for the department is the Statler Hotel, Room 1320.

The theam of the convention will be "Selecting, Organizing and Teaching Subject Matter for a Continuous Program in Science." Professor Ira C. Davis, University of Wisconsin, is in charge of the program. General sessions will be held each day at 2:00 P.M. with separate section meetings at 3:00 for Elementary Science, Junior High Science, and Senior High Science. A luncheon sponsored by the Detroit science teachers will be held Tuesday noon. Reservations should be made with Miss Florence Billig, 4743 Second Blvd., Detroit. Cost $1.25. On Thursday a joint meeting will be held with the School Garden Association of America.

WOMBAT & CO., INK MANUFACTURERS

By Charles H. Stone
Orlando, Florida

A definite tangible product and a use which can be demonstrated for that product constitute two strong means for enlisting the interest of the student in an assigned laboratory experiment. And when the assigned topic is broad enough to provide experimental material for a small group of students, so much the better. If, for example, the topic assigned is: "Lead and Its Compounds," something like the following may be arranged:

Student A. Collects maps of lead-producing states with the ore districts plainly marked on each, as: Joplin, Mo., etc. Such maps may be cut from old geographies which have been discarded.

Student B. Collects samples of lead ores. These may be obtained from the various lead-mining companies or from dealers in minerals.

Student C. Collects material on lead mining such as: pictures of mining operations in various places. Perhaps this student might also undertake a small model of a lead mine.

Student D. Collects information on the metallurgy of lead. Lead furnaces, ore flotation, etc. A model of a furnace might be made.

Students E, F, G, etc. Prepare a series of lead compounds such as: lead oxalate, sulphate, chromate, iodide, dioxide, red lead, nitrate, phosphate, arsenate, sulphide, etc.

At least one compound of lead should be assigned for preparation to Students A, B, C, D, so that every one taking part in the project has a chance to apply his knowledge of chemistry to the solution of the little problem assigned him. One student may be assigned "The Uses of Lead."

To answer the question, "What good is this product?" in any given case is not difficult. Certain lead compounds are used to color paint; others as the source from which other lead compounds are derived as; lead oxide to prepare lead nitrate, etc. The practical use to which the student's product may be put is an important point not to be missed.

The preparation of ordinary black ink is a project of this sort which lends itself readily to group assignment. Some five or six pupils may work together on this topic. The subject may be introduced in some such way as this: the teacher is going over some student's work in the laboratory when the following conversation may take place:

Teacher. Your work on hydrogen seems satisfactory. Once again tell me how you prepared this gas.

Student. It was prepared by the reaction between zinc and sulphuric acid.

Teacher. And what were the products?

Student. They were hydrogen and,—and—oh yes, zinc sulphate.

Teacher. And could you have used iron in place of zinc?

Student. Why, yes, I should think so.

Teacher. And what would be the products in that case?

Student. They would be hydrogen and, er, er, iron sulphate, I guess.

Teacher. You are right. Did you ever make any ink?

Student. No sir, I never did.

Teacher. Well, how would you like to make us some? Here are some iron nails.

Student. Ink from iron nails! But how—

Teacher. Oh, now you are asking me. You might look the matter up. And I suggest that a small group of you students work together on this thing for there is quite a lot to it. (And the teacher names a list of a few students who could work together on the project.)

Presently, over in a corner of the laboratory, Julius Wombat, Meyer Dumkopf, Maria Toofinger, David Sanswitzky, Angelo Scampini, and Bunkio Araki are holding a conference.

Wombat. Out of iron nails! He said it!

Bunkio. How can honorable nails to make these ink?

Sanswitzky. How is this inks made at all?

Wombat. Search me. But he said it could to be done.

Maria. Why don't we look in the book and find out about it?

Whereupon the group delves into the chemistry texts from which Scampini emerges with: "I got it. Here on page 458 it say: 'Black ink is made by mixing solutions of copperas and tannic acid. The product . . . ' "

Dumkopf. What are this tannic acid?

Bunkio. And the honorable copperas, he is what?

Wombat. Give it up. Why don't we go to the library in the free period and read up on this thing.

Accordingly, in the free period, six youngsters present themselves before the librarian declaring that to know about ink is the one passion of their lives and demanding that information thereon be set before them. The librarian, previously coached by the teacher, presents a list of references and the group is presently lost in encyclopaedias, technical books, special articles, etc. From these they emerge like the little Cratchits in Dicken's *Christmas Carol* "steeped to the eyebrows," not in

sage and onion, but in formaldehyde, tannic acid, copperas, gums and hydrochloric acid.

Another conference results in the assignment to Wombat, assisted by Bunkio, of the preparation of the ferrous sulphate; to Dumkopf is given the preparation of hydrochloric acid; Maria promises to bring specimens of gums and some formaldehyde, also "something else" from her brother's drug store; Sanswitzky declares: "I got me an uncle what has a wooden yard; I gets me some hemlock barks off from him for to make the tannic acid." Scampini is to dip into the matter of secret inks. Each goes busily about his assignment.

By and by announcement is made that all things are ready. Five grams of powdered copperas are dissolved in 25 cc warm water and the solution filtered. Five grams of tannic acid are also dissolved in water and the solution filtered. The two solutions are now poured together with high expectations. Consternation!

Bunkio. What ail these ink? It write not!

Dumkopf. Probably tannic acid of Sanswitzky no good.

Sanswitzky. It is either!

Maria. Simples! Didn't you read where it said that ferrous tannate is colorless while ferric tannate is black?

Scampini. Sure we read on it. But how . . . ?

Maria. (Producing her "something else") Try this. You have to oxidize the ferrous tannate to ferric tannate.

Ten cc of the fresh hydrogen peroxide are now stirred into the liquid and the immediate blackening is apparent to all. A toothpick dipped into the liquid leaves black marks when drawn across some paper. Hooray!

(Think not, gentle reader, that this ink surpasses Waterman's Best; it doesn't. But to these youngsters, it is THE ink for it is black and you can write with it.)

Some powdered gum arabic is now stirred in to give the ink body and a few drops of formaldehyde will keep it from spoiling while a little hydrochloric acid will prevent any hydrolysis of the iron salt. Altogether, they are well pleased with the results obtained.

At the teacher's suggestion, the various materials are assembled and made into an exhibit, the finished ink being put up in a bottle while the other materials are displayed in small test tubes properly labelled. Beside each tube is placed a small sticker bearing the name of the contributor.

Finally the teacher assigns a ten minute space in which the topic INK is presented, each of those taking part in its preparation putting his matter before the class with descriptions, equations, etc. At the end, Scampini interests the class with some experiments on secret inks such as: cobalt chloride writing on pink paper which is later to be warmed; mercurous nitrate writing on white paper to be developed with ammonium hydroxide, etc. And so ends the adventure of Wombat & Co., Ink Manufacturers.

An occasional departure of this kind from the usual type of laboratory experiments adds greatly to the interest. When these pupils have worked out for themselves the problem of ink making, they cannot help having acquired a good bit of chemistry along with the fun of the preparation.

ALEXANDER HOWARD McCONNELL

With deep regret we record the death on May 4th of Mr. Alexander H. McConnell, Chairman of the Board of Directors of Central Scientific Company. Mr. McConnell was a promoter and benefactor of scientific education as well as an esteemed citizen and progressive business man. The company he founded and the quality of its products stand as a monument to his industry and ideals.

ABOLITION OF MATERNITY IS PRICE OF FULL EQUALITY FOR WOMEN

Women can achieve full equality with men, full freedom such as the male sex enjoys. But only if she pays for it with her function of motherhood.

So declared Dr. Edwin Grant Conklin, emeritus professor of biology at Princeton University, in the first Westbrook Lecture which he delivered at the Wagner Free Institute of Science.

Dreams that babies can be produced "ectopically," that is, by laboratory methods outside the mother's body, Dr. Conklin characterized as "vain imaginings." So too, with the super-socialistic notion that a few women, selected as "race mothers" to produce all the children while all the rest are free for their careers. If there are to be children, if the race is to continue, it will have to be the age-old biological method, he declared.

Dr. Conklin is not haunted by the "Malthusian ghost," bugbear of many sociologists. "Science has created a human population problem by increasing the means of living and decreasing the death rate," he admitted. "However, overpopulation is limited to certain places or peoples, and it soon corrects itself. There is now more danger of underpopulation in Western Europe and North America than of over-population."

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Thirty-fifth Meeting

HELD AT RINDGE TECHNICAL SCHOOL

Cambridge, Massachusetts,

in conjunction with and following the
Conference With Teachers of Science at
Harvard University, Graduate School of Education.
Saturday, March 27, 1937

PROGRAM

At the Institute of Geographical Exploration

10:00 Conference With Teachers of Science. Mr. Homer W. LeSourd, Chairman. Topic for discussion:—What Can Be Done by Science Teachers' Organizations to Raise the Standards of Teaching and to Improve Teaching Conditions in the Field of Secondary-School Science?
Principal Speaker:—Dr. Morris Meister of the New York City School System.

At the Rindge Technical School

11:30 Address: Mr. John W. Wood, Head Master, Rindge Technical School.

11:45 Address: The Place of Physics in An Integrated Science Course for Secondary Schools. Professor Charles E. Stratton, College of Business Administration, Boston University.

12:15 Lecture Table Experiments and Demonstrations by Member of the Faculty of the Rindge Technical School.

1:00 Luncheon.

1:45 Business Meeting.
Report of the Committee on Magazine Literature and New Books. Mr. Carl W. Staples, Chairman.
Report of the Committee on Current Events. Mr. John B. Merrill, Chairman.
Report of the Committee on College Entrance Requirements. Mr. Burton L. Cushing, Chairman.

2:15 Inspection of Laboratories, Shops, and Special Equipment of the Rindge Technical School.

OFFICERS

President, LAWRENCE A. HOWARD, High School, East Boston, Mass.
Vice-President, ROBERT W. PERRY, High School, Malden, Mass.
Secretary, WILLIAM W. OBEAR, High School, Somerville, Mass.
Treasurer, PRESTON W. SMITH, 208 Harvard St., Dorchester, Mass.

CONFERENCE WITH TEACHERS OF SCIENCE

Under the auspices of the Graduate School of Education, Harvard University

Members of the New England Biological Association, the New England Association of Chemistry Teachers and the Eastern Association of Physics Teachers, with many guests, comprised the large audience at this conference. An interesting feature was the presence of many charter members and past presidents of the three associations. The E.A.P.T. had present fourteen past presidents and two charter members, Mr. Packard and Mr. Palmer. The Chairman, Mr. LeSourd, introduced the Presidents of the three associations and each of them responded.

Mr. Howard, President of the E.A.P.T. spoke as follows.

"With the value of teachers' organizations now so generally accepted, you will, I am sure, pardon us if we boast a bit about our age. We believe that the E.A.P.T. was the first special group of secondary school teachers to be organized in this country. Over forty years ago some of our fellow-workers in the field of physics saw clearly the advantages to be obtained through association with others who were striving toward the same goal and who were confronted with similar problems. The call for the first meeting was issued by Dr. John C. Packard, at present the Head of the Department of Science in the Brookline, Mass., High School, and organization, with Dr. Packard as President, was perfected on Feb. 2, 1895. The enthusiasm and unselfish efforts of the founders immediately produced results which made a wide appeal. Number of members increased as did the territory from which they were drawn, until today every New England state is represented in our membership. Both private and public school teachers are found on our rolls, and we are proud to include several pro-professors of physics in New England Colleges.

"Meetings are held at various schools and colleges, affording an opportunity to inspect a variety of equipment and to become acquainted with The work being done in a large number of institutions. Authoritative speakers are heard on different phases of research, on applied physics, and on the theory and methods of teaching the subject. We have committees constantly at work to keep us posted on new books, magazine literature, current events, and new apparatus. A committee on college entrance requirements is in touch with the C.E.E.B. and is now engaged in constructing a new syllabus to be recommended to that organization. Reports of our meetings are printed in SCHOOL SCIENCE AND MATHEMATICS and a subscription to this publication is included in our membership fee. All these are advantages to be obtained from membership in the organization. But there is yet another which is far from unimportant, and that is the contact with others in the same branch of the profession."

WHAT CAN BE DONE BY SCIENCE TEACHERS' ORGANIZATIONS TO RAISE THE STANDARDS OF TEACHING AND TO IMPROVE TEACHING CONDITIONS IN THE FIELD OF SECONDARY-SCHOOL SCIENCE?

(Outline of an address by Dr. Morris Meister, Science Supervisor, N. Y. City Public Schools)

I. Science Teachers' Organizations in New York City
   A. The General Science Teachers Association
   B. The Biology Teachers Association
   C. The Physiographers and Geographers Club

D. The Chemistry Teachers Club
E. The Physics Club of New York
F. The Science Section of the New York Society for the Experimental Study of Education

II. Dr. Tildsley's Report: "Science Teaching—A Way of Life" and its effect upon Science Teachers' Organizations
   A. The Science Council, a representative body, fusing the work of the groups listed under I, above
   B. The Standing Committee on Science, a small executive committee with one member for each of the special subjects
   C. Activities of the Council and the Standing Committee as an experiment in "democracy in education."

III. Certain Special Activities of Teachers' Organizations in New York City
   A. Evaluation and Selection of Motion Picture Films
   B. Production of Teaching Films
   C. Organization of Museum Exhibits
   D. Committees on Science Teaching Supplies
   E. Committees on Effective Teaching Demonstrations
   F. Science Film Centers
   G. Selection and Licensing of Science Teachers
   H. Desirable Training for Science Teachers
   I. The Children's Science Fair and Junior Science Club Movement
   J. "Alertness" courses for In-Service training of science teachers
   K. The "Case" Study, now in progress, on Improving Teaching Methods for the purpose of developing scientific habits and attitudes
   L. A W.P.A. Project on Science Teaching Models (slides showing 20 models already built).

IV. Indicated Conclusions and Recommendations
   A. The need for cooperation and unity among different science teachers' organizations.
   B. The need for a single national professional journal dealing with problems in science education.
   C. The need for cooperative research and study of certain important and immediate problems in science teaching.
   D. The possibilities for unification of effort through The American Science Teachers Association, now in its fourth year of existence.

PHYSICS

By John W. Wood, *Head Master, Rindge Technical School*

Can the subject of physics be taught to yield a more comprehensive knowledge of natural phenomena than is obtained from current courses in the subject, together with a richer first-hand experience of significant applications through laboratory manipulation, and can such teaching be freed from unnecessary mathematical complications?

It requires considerable courage for one who is not a specialist to put such a question to this distinguished gathering. There are signs, however, that an adequate answer would be welcome to many who are somewhat bewildered by the present situation.

(1) To cite only one instance which has arisen. In the latest revision of his text on *Elementary Electricity*, Timbie says that the most significant progress in electricity in the past ten years lies in the field of electronics. Recently we have been working on this same subject in order to arrange a course for our radio class. We felt that to confine our attention to this single application (radio) tended to narrow unduly our instruction in this field. Through the kindness of the General Electric Company, we were fortunate enough to obtain a carefully planned course including a series of experiences, all carefully correlated with the necessary theory. If you have not yet seen these books, you might be interested to obtain copies.[1] I doubt whether the course, together with the fundamental instruction in electricity which is presupposed in the student's preparation, could possibly be covered in less than two years with a time allotment of five periods per week, and yet it is entirely within the range of secondary school comprehension.

(2) At the risk of seeming irrelevance, let me cite an experience of a totally different character. In discussing certain phases of laboratory work in mechanics, a teacher of long experience, for whom I have great respect, argued against the use of pulley blocks, wheel-and-axle, and such rudimentary examples of simple machines, because the results obtained would not agree with the formula in the textbook, with consequent lack of confidence of the student in his book. One may have sympathy with such a point of view, if the student is never, under any circumstances, to put his learning to any practical use. In the current educational phraseology one would say that this is the "totally unsocial" point of view. What a lot of this sort of thing we do in physics. Think of the time spent in teaching such mythical concepts as uniform motion, uniformly accelerated motion, and the others which we know so well, which exist only in a purely ideal world.

(3) Again changing the subject, I should like for a moment to look at the question of the relation between mathematics and physics. I can remember very clearly spending time in the physics class in teaching:

(1) The metric system
(2) Ratio and proportion and variation
(3) The various formulae which arise from Newton's Laws of Motion and the manipulation of formulae for various unknown quantities
(4) The various units in which these quantities may be expressed and the equivalence of the units
(5) Ohm's Law and various resistance formulae. These rather hurriedly, indeed, because electricity was in the back of the book, and I had used up too much time before I got to it.

Probably you are wiser than I was, and perhaps you don't do any of these things. But in an article in the March number of *The Mathematics*

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[1] Laboratory Experiments on Electron-tube Theory. GET 566.
Laboratory Experiments on Electron-tube Applications. GET 620.
Electronics and Electron Tubes. GET 568A.

Teacher,[2] I find an interesting discussion of this very question, which seems to suggest that at least a few teachers are still struggling with our old enemy. The author says: "The opinion is that the physicists usually take sufficient work in mathematics. The complaint is made that the courses, in many instances, are not satisfactorily taught.—It is unfortunate that many departments of mathematics are so little concerned with the application of their science to physics, for the satisfaction of whose demands most mathematics has been developed." One is tempted to think that the physics teacher himself must bear part of the responsibility since he so cheerfully shoulders the responsibility of teaching both mathematics and his own subject to his students. Why not start a sit-down strike? Leave the metric system, vector addition and subtraction, acceleration without change in speed, and other purely mathematical concepts to be taught elsewhere. For example, velocity and acceleration. The mathematician will say, "distance expressed as a function of time has for a first derivative velocity or speed and the second derivative of this distance-time function or the first derivative of the velocity-time function is acceleration"—a neater, more convincing and time saving method than any we can devise. In the mean time, we can turn to certain nomographic methods to give practical assistance in the physics class.

And most surprising of all, Professor Tucker of the Massachusetts Institute of Technology told us the other day that they are developing a course at the Institute which does not use Ohm's Law and does not miss it. I have a friend who is an expert in lenses who taunts me now and then with the positive assertion that the formulae we teach in elementary physics are incorrect and would be of little or no value if they were eternally true.

To add still one more irrelevance to my list, already overlong. Two years ago the College Entrance Examination Board set an examination in physics which contained the usual number of questions. And to my great delight only an insignificant number of them required a mathematical answer. Resorting to the telephone, I immediately called up a friend whose judgment I respect in these matters and enthusiastically proclaimed this change in policy. He refused to enthuse (perhaps he didn't agree with me anyway), but assured me that I was rejoicing not at a change of policy but over an accident, and that next year the Board would return to the old basis—and it did.

Now how shall I draw this desultory meandering to a conclusion?

(1) There is in physics a greater embarrassment of riches than in any other high school subject with which I am acquainted, and we can depend upon the future to bring in greater supplies of this real gold. I mentioned electronics as one of the newer subjects pressing upon our attention. Closely tied up with this subject is the whole fascinating story of the theory of the electron. Adaptable to high school instruction? We think so.

(2) Is the answer to this richness of material at our command a so-called

[2] *The Mathematics Teacher* March, 1937. Karl F. Oerlein, "Math Difficulties in College physics," p. 127.

survey course? Perhaps, but I hope not. I distrust any approach to physics which seems to make it possible to substitute any activity for laboratory work. It is possible that laboratory methods may have to change. One method which we have tried seems to have possibilities in that it avoids an impossible duplication of apparatus. Briefly it presents a number of different experiments to be performed in any convenient sequence, with two or more students working with the same apparatus. Whatever modifications we may have to resort to, I hope that the laboratory will always stand first in our esteem, as it is the only way to get first hand contact with reality.

(3) And finally, I am afraid that I become each year more and more impatient with the dominance of mechanics in the teaching of physics. Most of this subject, as I have suggested, is better taught in the mathematics class and the balance is a laboratory and museum subject. How about such a question as this—"Would a gram of force at the sun be greater than a gram of force at the earth's surface?" Don't misunderstand me. I would not emasculate physics or leave it a spineless thing beneath the contempt of a real teacher. I would not leave out all mathematics from physics. But I would weigh in the balance the relative value of "grams in the sun" and polarized light in the laboratory and consider also whether physics has value only for those who are mathematically minded. I believe it is a subject of primary importance for everyone—boy or girl, college candidate or business candidate, genius or average. I have been extremely interested in a text recently prepared by Mr. Hodgdon, one of our colleagues at Rindge, which begins by discussing the modern theory of the electron. Why is the only proper order the traditional one, through metric equivalents, matter, mass and the simple machine? I found myself interested in Mr. Hodgdon's book and reading along with great pleasure in spite of the fact that a physics text is a very old story to me.

Finally, there are such a number of interesting and worth-while things to fill the time saved on out-moded activities. An example of this is in a study of the molecular structure of metals and some of the practical results of their arrangement in the material tested. This study leads quite naturally and without forcing, to a chemical investigation which supplies some quantitative aspects of the subject. And again let me repeat—this is all on the high school level.

Let me end, as I began, with this statement—that I hope the future of physics is directed toward greater breadth of knowledge of natural phenomena, more first hand contacts with significant apparatus, and that the whole may be taught without too great mathematical complication.

THE PLACE OF PHYSICS IN AN INTEGRATED SCIENCE PROGRAM

By Prof. Charles E. Stratton, *Boston University*

In almost all subjects except science there is a continuity which is recognized throughout the curriculum. If we think for a moment of the work in

mathematics, English or history, we will see that the courses are organized so that they form one continuous whole throughout the pupil's stay in school. In science, however, the various parts seem to have been developed as separate units, and it is primarily the fault of the physics teachers, since they were amongst the earliest in the field, that they have not recognized the necessity of coordinating the whole field of science into one integrated and continuous program.

Let us pause to consider the various subjects which compose the field of science as taught in the elementary and secondary schools. In the earlier years the children have nature study, health studies, physical geography and some biographical studies of great men of science and invention. In the junior high school we perhaps have two years of general science and in the senior high school one year each of biology, chemistry and physics; and it is my purpose this morning to consider with you the place of physics in a system in which it will be coordinated with all these earlier units. While it is necessary that our physics teachers should know something about the subject beyond that which they teach, it is essential in my opinion to a far greater degree that they should know a great deal about the subject matter which precedes physics. I would have every science teacher trained so that he or she could teach and teach well all of the subjects which are taught in this field in the elementary and secondary schools. We would not think very well of the mathematics teacher who could only teach algebra and who knew little of the commercial arithmetic of the grades and knew nothing of trigonometry and geometry. I do not mean by this that it may not happen that a teacher who has a full knowledge of a particular field may not prefer to teach that particular part of the whole. I heard in one of these meetings recently a plea for more time for physics—that there was not now sufficient time in which to teach the subject. My plea would be for more time for science as a whole.

In an article by Morris Meister in the November 1932 issue of SCHOOL SCIENCE AND MATHEMATICS, he indicates that the years from 1925 to 1930 saw an intensive attack on the program of reorganizing the courses in biology, chemistry and physics so that they too might carry on from where general science leaves off, and so that they might themselves harmonize with each other in promoting the aims of education; and I would further add that this reorganization to my mind is still going on and we as physics teachers, I believe, do recognize that we must take a definite position as to the lines on which this reorganization is to continue. I believe that most of our trouble lies in the lack of a complete understanding of what the pupil knows or is expected to know before he comes into our physics classes.

Let us assume an ideal program in science for our schools and review briefly the material which the student would have had before he started the physics course in the last year of high school, which seems the logical place for such a course.

I am assuming that such a course would, throughout the first six years, treat with nature study, health, and physical geography, and probably not

until after the seventh year be so organized as to have well-defined courses in general science. That would leave the seventh, eighth and ninth years for this study of general science, the tenth year a course in biology, the eleventh year a course in chemistry, and in the twelfth year a course in physics.

In examining a number of texts in general science I found that ordinarily about 300 out of 600 pages are given to the general study of physics, and it would seem to me that this represents about half of the material that is ordinarily included in our physics texts.

Looking at a standard biology such as would be used in the tenth grade I find that among the topics considered are air, both from its physical and chemical aspects, temperature and thermometers, water, capillary action, and osmosis, to mention just a few of the places in which the child is brought further in contact with the physical principles.

From a standard chemistry book such as would be used in the eleventh year I find the following list of subjects treated, vapor pressure, absolute zero, Boyle's Law, atmospheric pressure, planetary electrons, Brownian movement, boiling point, light, conservation of energy, electrolysis, electric furnace, filtration, freezing points, ionization, liquid air, malleability, positive ray analysis, quantum theory, radiation, spectroscope, specific gravity, specific heat, and wave theory of matter.

I hope that this brief survey of the material in the courses which precede the physics course suggested to you the same things that it does to me, namely, that our physics course, which is the last course in the high school in science, must now become a broad general review course much in the same way as we have found it advisable to give a survey course in mathematics in the last year of high school. This physics course, in the first place, should reduce many of the principles which the students have known in a general way to mathematical formulae, since many of these have no real meaning until they are so reduced. It can draw its problems from a wide field of science, from astronomy, geology, chemistry, biology, and in this way review many of the things that are taught in these varied sciences. It may eventually lose its title as physics and be called a general survey of the physical sciences.

We might well stop to ask the question, What kind of a course, then, will we give in physics; and I have one suggestion, namely, that the time allotted to physics for high school seniors should be spent in doing practical problems, and the verification of these problems should take place in the laboratory. By the time that the student is a senior he comes to us knowing some mathematics and a good deal of general science. We should be able then to propose to him practical problems for whose solution he is mentally well equipped and which can be readily verified in our laboratories. I will, therefore, suggest a few problems taken from the various units of physics which I think might well be adapted to such a treatment. Many others will, of course, occur to you.

When you and I have a practical problem to solve we collect all the material that we can find on the particular subject, we make up our

minds as to a proper solution, with various diagrams and mathematics we compute the various elements that come into the problem. We decide upon the answer and then verify our results. Why not apply the same principle in our work in physics? Take this problem, for example:

A rectangular block of wood is floating in water. How large a volume of lead would it support without sinking, (1) if the lead is placed on top of the block, and (2) if it is suspended in the water beneath the block?

To compute the result it would be necessary to know something about density, Archimedes' principle for both floating and sinking bodies. I think that most students before they come to the physics course know the general principles involved, but up to this time have never been called upon to use these principles in solving a really practical problem. I believe that the boy should have available in the physics laboratory all the science books that he has used in previous courses. The teacher is there to answer the questions called up by a statement of the problem and to lead in the discussion of new material. After a solution of this problem is obtained by the student, I would send him to the laboratory to verify his results.

If you do not think that he should know a sufficient amount to be able to do this problem, I could refer you to *The World Around Us*, by Powers, Neuner and Bruner, pages 96–103; *Exploring the World of Science*, by Loeb, Harley and Welton, pages 105–109, and to almost any standard general science text. With that text in front of him and the physics book for the course, I believe he would be ready for the problem.

For a second problem, perhaps one in mechanics: To find what single force and where it should be placed to support in equilibrium a heavy iron bar on which three weights were hung at different points.

A third problem: To devise an optical system by means of which a person could see a letter on a piece of paper ten inches to the left of a point four inches from his eye and directly in front of his eye.

Such a system could be devised by means of mirrors or prisms. In fact, the optical system suggested in the problem might be a much more complicated one than the one I have suggested.

As we survey the field of physics many problems would come to our minds as problems which would involve the principles that the boy already knows and which only a little instruction on our part would recall to his mind if we knew that he was expected to know this particular principle.

The book, *Exploring in Physics*, by Stephenson, published by the University of Chicago Press, would give many suggestions of problems such as those which I have mentioned.

If I have made my meaning clear you will see that I am trying to suggest to you that physics is just the next step beyond general science. It is making use of the principles which have already been taught the student, and only as you step beyond the point where general science has gone are you going to teach new material, but in most cases are teaching him simply how to apply the principles that he has already learned. I know you will

say that I am assuming a good deal when I say "already learned," but I would draw to your attention the fact that I find college men and women today who cannot add and subtract, and yet no one would argue but that they had been taught addition and subtraction some time in their earlier education. So we must not make our courses dull with repetition just because there are a few students who did not learn certain underlying principles when they should have. With the general science book in their hands they will be given another opportunity to review.

In closing I would say that in the reorganized physics I believe much of the time should be spent in teaching the pupil to apply the principles which he has already at least partially understood before he comes to the physics course.

THE CATHODE-RAY OSCILLOSCOPE

By Arthur F. L. Morash, *Rindge Technical School*

The vacuum tube has made possible many of the marvels of modern science and engineering. The most important application of this device has been perhaps in the field of communications and it is probably safe to say that without the vacuum tube broadcasting as we now know it would be a fantasy instead of the indispensable actuality it really is. The cathode-ray tube—a comparatively recent development in the vacuum tube field—has placed in the hands of the scientist, engineer and educator another powerful tool of the electronic type. Employed as an oscilloscope it makes possible the qualitative and quantitave study of an endless variety of slow speed and high speed steady-state and transient phenomena.

The cathode-ray tube is an electronic device embodying many of the characteristics and elements of the type of vacuum tube found in a radio receiver or transmitter. Figure 1 illustrates the component parts of the cathode-ray tube. It consists essentially of an electrically heated cathode constituting the source of electrons together with a number of control electrodes all contained within an evacuated glass bulb. The end of the bulb opposite the cathode is flared out so as to form a circular window the inside of which is covered with chemical compounds which fluoresce strongly when bombarded with electrons.

In studying the subsequent action of the cathode-ray oscilloscope it will be well to keep in mind that an electron is a negatively charged particle of electricity with a mass of $9{\cdot}0\times10^{-28}$ gram, a radius $\frac{1}{1847}$ that of an hydrogen atom or $1{\cdot}9\times10^{-13}$ centimeter. Also that an electric current having a flow of one ampere is equal to or may be defined as a flow of $6{\cdot}3\times10^{18}$ electrons past a given point per second. Let us now turn our attention to Figure 2 which is the optical counterpart of the cathode-ray tube. It consists of a source of light I, an adjustable aperture A, a system of lenses L_1 and L_2, and a screen S. The amount of light reaching the screen

will of course depend upon the diameter of the aperture A while the sharpness of focus at P will be determined by the adjustment of the two lenses L_1 and L_2. The focusing may be accomplished in a number of ways. One method would be to move one lens with respect to the other or both lenses could be adjusted at the same time. Another method would be to change the contour of the lenses, while still another would be to vary the indices of refraction of the lenses. It is this latter method with which we are particularly concerned. Let us now compare the above action with that taking place within the cathode-ray tube.

The electrons emitted by the hot cathode are attracted to anode 1 and anode 2 by connecting the positive terminal of a high voltage source to them with the negative terminal to the cathode. Both anodes have openings placed axially. Many of the electrons reaching these anodes have sufficient kinetic energy to continue on through the openings to the fluorescent screen at the window end of the tube and the result of these electrons impinging on the screen at high velocity is a bright glow. Now by connecting a negative voltage to the grid situated between the cathode and anodes it is possible to control the number of electrons reaching the anodes and hence the screen, thus the grid is equivalent to the aperture of the optical analogue. By now varying the ratio of the positive voltage on anode 1 with respect to that of anode 2 the beam of electrons impinging on the screen may be focused to a sharp point at the screen. It is interesting to note that a variation of the voltage ratio is equivalent to a change of the indices of refraction of the lenses of the optical analogue. For a sharp focus the ratio is on the order of 5 to 1 with the voltage on anode 2 the highest and constant, the change in ratio being accomplished by changing the voltage of anode 1. That part of the tube comprising the cathode, grid and two anodes is referred to in practice as the "electron gun."

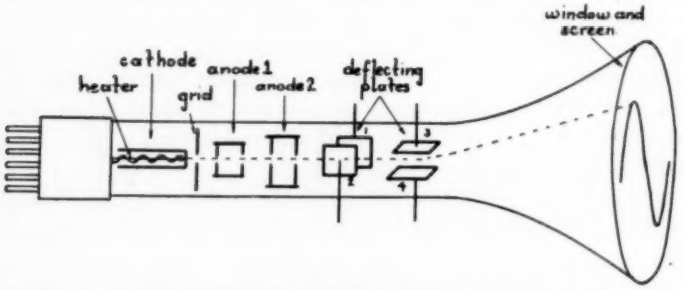


FIG. 1. Connections to the heater, cathode, grid and anodes are made to the base prongs.

The remaining features of the tube are the two sets of deflecting plates mounted axially between the second anode and the screen. By alternately placing a plus and minus voltage on plates 1 and 2 the electron beam is moved back and forth horizontally and a bright line as shown in Fig. 3 is traced on the fluorescent screen. In like manner if plates 3 and 4 are al-

ternately polarized plus and minus, a vertical trace appears on the screen as in Fig. 4. Thus we have the equivalent of the horizontal (H) and vertical (V) axes of Cartesian or rectangular coordinates. Suppose a voltage is now connected to plates 1 and 2 which varies linearly with respect to time. Such a voltage may be generated by the well known vacuum tube saw-tooth oscillator the wave form of which is depicted in Fig. 5. The trace of this disturbance would appear on the screen as that of Fig. 3. With the saw-tooth voltage connected to plates 1 and 2 (horizontal) let

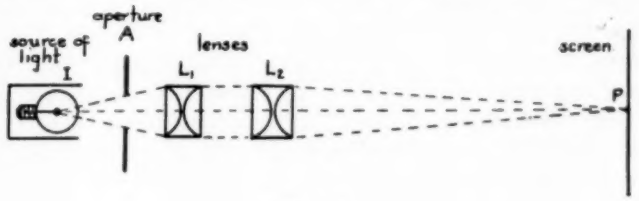


FIG. 2

us now impress a sinusoidal voltage on the vertical plates 3 and 4 and there results on the screen a trace of the well known sinusoid in rectangular coordinates as shown in Fig. 6. If sinusoidal voltages are impressed on both horizontal and vertical deflecting plates simultaneously a wave form known as a Lissajous Figure results. The Lissajous Figures shown in Figure 7 are obtained when the two sinusoidal voltages on the deflecting plates are 0°, 45°, 90°, 135° and 180° out of phase with respect to each other.

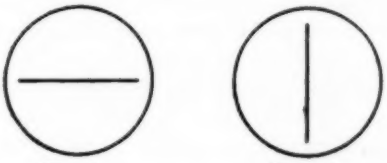


FIG. 3 FIG. 4

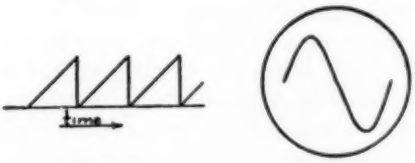


FIG. 5 FIG. 6

FIG. 7

While the deflection of the electron stream in the cathode-ray tube just described was accomplished electrostatically, it is important to note that the same result may be obtained electromagnetically by two sets of coils placed external to the tube with their axes perpendicular to each other and and to the axis of the tube.

The uses of the cathode-ray oscilloscope are legion. Because of the negligible mass and hence inertia of the electron beam together with its practically instantaneous response to low intensity electrostatic and magnetic fields, many different types of phenomena may be observed. Data for wave form and frequency determination, peak voltages, line surges, oscillatory discharges are readily obtained. A graphic picture of the performance of a radio transmitter may be had showing percentage modulation, signal distortion and other factors pertaining to correct station performance. To the radio-repair man the cathode-ray oscilloscope offers a quick and easy method for the alignment of intricate circuits such as are employed in the modern superheterodyne receiver. The automotive mechanic with this device is able to check the performance of ignition systems at high engine speeds and obtain a correct picture of spark plug action during actual operation. The cathode-ray tube is also used in television reception.

At the present time the cathode-ray tubes ordinarily used have window diameters of one, three, and five and nine inches. The light emitted by the fluorescent screen is sufficiently strong to be observed in daylight. The light is also actinic thus allowing a permanent photographic record of the trace to be obtained if desired.

VALUE OF NOMOGRAPHIC CHARTS IN THE TEACHING OF PHYSICS

By Albert Coyne, *Rindge Technical School*

I have been asked to say a few words relative to the construction, use and value of charts in the teaching of physics.

The questions arising in your minds are, what kind of charts and how could they be of service. Basing your mental picture on the charts with which you are most familiar, I daresay you anticipate hearing something about the one familiar to many physics classrooms containing encyclopedic information of a veritable myriad of standard equivalents made voluminous by such information as the number of pounds equaling one stone, the essential units of both Troy and Avoirdupois weight tables and a unit of measurement known as a hand equaling four inches, etc. The student is told that all of these units are still used to a degree, even the last named, which is still the unit to describe the height of a horse.

Let us see what may be said by way of justification of computing charts. It would be interesting to know just how much time is spent by the student of high school physics in fixing a concept of the relationship of the

two systems of lineal measurement: the metric and the English systems. We arm the student with the information that a meter is one-ten-millionth of a quadrant of the circle of the Earth measured from the pole to the equator, and that a bar of this length is preserved in Paris. The geography of this statement is his forever. When thus motivated we casually inform him that he must remember that 2.54 of 1/100 of this measure in Paris is equal to one inch, or if he found this difficult, that 39.37 inches is equal to this standard. Unless he can retain a mental perception of the English yard he will find this second statement equally as difficult. We then start to drill our way out of the resulting confusion with countless examples depending on facility in arithmetic and memory. When the process is considered learned will the student readily discern errors of computation that one with a well founded concept of the relation, would consider obvious? May he not fail to recognize the conversion of 500 cm. as approximately 200 inches, but instead, relying upon his arithmetic and the proper placing of the decimal point be satisfied with results such as 20 or 2000? This illustration may seem grotesque, but very few teachers will venture to say that the present day high school student has passed the danger of faulty computations.

The conversion of units of one system of lineal measurements to another system is but one of the countless transitions, a reasonable knowledge of which we deem advisable and which we may call a quantitative concept. To achieve this goal would be a worthwhile accomplishment at most any reasonable expenditure of time. The computing chart offers an efficient auxiliary method. It would be interesting to know what per cent of the time in the first year of Physics instruction is devoted to arithmetical drill. It is safe to say more time than the teacher desires. He repeatedly is required to stop and give type examples to fix a process of approach. Could any part of this time be turned into a laboratory exercise to accomplish the same end? Perhaps it could by requiring each student to construct a conversion chart on which he could do many problems and observe the rate of change in quantities. I venture to say that a small amount of this simple pleasurable exercise will do as much to fix a relationship as tedious hours of arithmetical drill.

Therefore to answer the first of your questions let me say that the charts we will discuss are only the more simple ones, and only those of the student's own manufacture. I stress this point because in my opinion the greatest possible good only comes when these charts are the results of individual efforts. For the teacher to select a particularly good one and keep it for the use of the entire class or for future use would nullify much of the benefit coming from such an experiment. The charts I wish to show are all based on the relationship of similar triangles with uniform scales. They are but stepping stones to the more complicated manipulation of logarithmic scales and moduli designed to satisfy conditions as set forth by many types of scientific and engineering formulae.

On the first chart which I will call a conversion chart the student need

not place at the outset a large number of critical points but may keep pace with the content of his course. In making such a chart he will quickly find that accuracy is essential and that equal degrees of accuracy will not always produce equally reliable conversions. For example he will quickly see that a ratio as gallons to cubic feet expressed numerically 800 to 107 will produce a critical point quite unreliable but if he will multiply each part of this ratio by constant that will enable him to cross the transverse more nearly normal the result will be correspondingly more accurate. This chart might be likened to a slide rule or many slide rules permanently set at definite ratios to be used in checking results. This conversion chart is made by placing equal and similar triangles ABC and $A'BC$ together. The sides AC and $A'B$ are graduated with any convenient unit of measure. The side BA' is extended to enlarge the range especially of conversion of equivalents where the ratio is similar to that of the inch to centimeter (1:2.54). If this were not done we could only conveniently

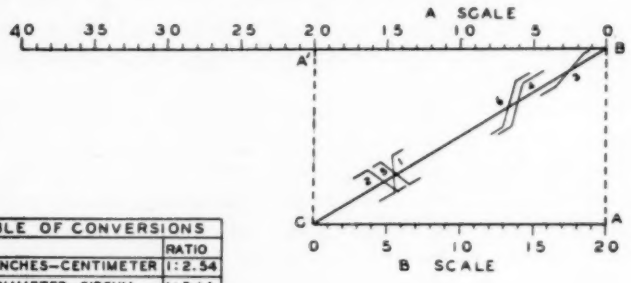


TABLE OF CONVERSIONS		
NO.		RATIO
1	INCHES–CENTIMETER	1:2.54
2	DIAMETER–CIRCUM.	1:3.14
3	GALS.–CUBIC FEET	800:107
4	FT. H$_2$O–LBS. PRES./0"	80:28
5	MILES–KILOMETERS	22:57
6	IN. Hg–LBS. PRES./0"	57:28

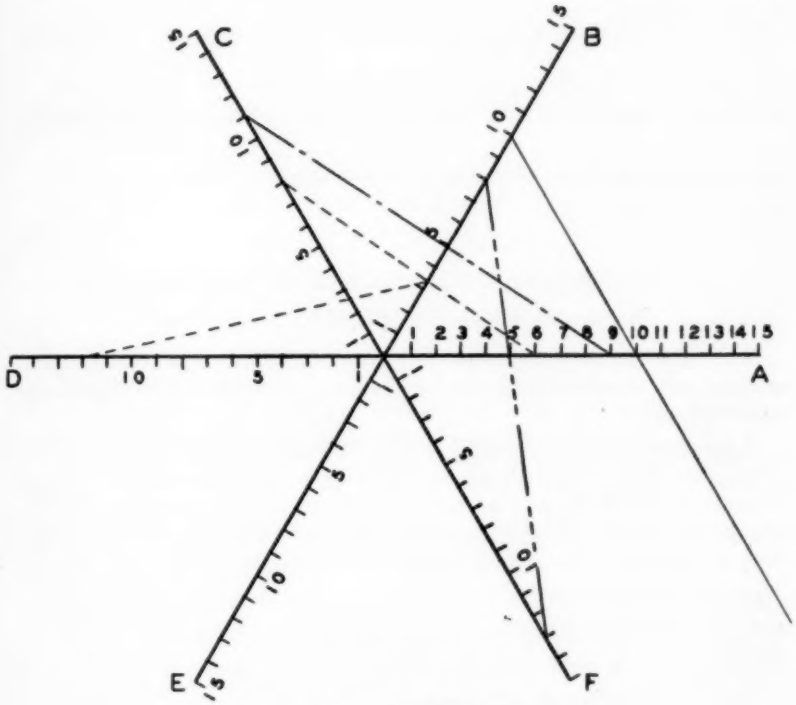
Conversion Chart

convert inches to (8×10^{n}). A simple method for a student to either compute conversions or to check his results is to place a needle point at the critical point on the diagonal and then with a straight-edge extending from a value on scale "B" through the critical point may read his answer on scale "A." He may thus readily see how one value increases with a unit increase of the other. Space does not permit a more extended treatment of the interesting processes such as intermittent work problems and production problems that may be accomplished with this type of chart.

Let us next look at the computing chart. This is formed by placing six similar triangles together in a rotary manner. This suggests the possibility of extended operations in the form of the equation $\frac{1}{R}=\frac{1}{r^{1}}+\frac{1}{r_{2}}+\frac{1}{r_{3}}+\cdots\frac{1}{r_{n}}$ or the total resistance of conductors in parallel. Let us follow

the solution of a typical problem. Let the resistances $r_1 = 6$ Ohms, $r_2 = 8$ Ohms, $r_3 = 12$ Ohms. What will be the total (R) resistance? Follow the dotted line · · · . From division 6 on scale "A" to 8 on scale "C" we find the intercept at about $3\frac{1}{2}$ on scale "B." From this point to division 12 on scale "D" we find the intercept at $2\frac{7}{8}$ or 2.67 on scale "C." (Answer 2.67 Ohms.)

This form of chart lends itself to the solution of various problems in Optics. For example in solving for focal length $\frac{1}{F} = \frac{1}{D_i} + \frac{1}{D_0}$ (for real



Computing Chart

image in converging lens). If D_i equals 9 cm and D_0 equals 11 cm solve for F. Follow the dot-dash line from a point 9 on scale "A" to a point 11 on scale "C." We find the intercept at slightly less than 5 on scale "B." The answer is 4.95 cm. For the formula $\frac{1}{F} = \frac{1}{D_0} - \frac{1}{D_i}$ (for unreal image in converging lens) we merely have to rotate in the other direction. For example let $D_0 = 5$ cm, $D_i = 13$ cm. Find F. Solution. From point 5 on scale "A" draw line (dash-3 dots — · · ·) to point 13 on scale "F.")

On scale "*B*" we find the intercept at 8 plus (Answer 8.12 cm. For the formula $\frac{1}{\alpha}-\frac{1}{D_i}=\frac{1}{F}$ where the object is infinitely far away where will the image be? Solution. (full line) From a point 10 on scale "*A*" to a point α on scale "*F*" (parallel) we find an intercept at 10 on scale "*B*." (Ans. equals 10 cm equals Image Distance.)

Finally, returning to the Conversion Chart we find by placing two scales on scale "*A*" (one inside and one outside) and two scales on scale "*B*" (one inside and one outside) we may solve an equation of the form $\frac{V_1P_1}{T_1}=\frac{V_2P_2}{T_2}$ involving six variables, by equating each side of the equation to *K* (Constant) as $\frac{V_1P_1}{T_1}=K=\frac{V_2P_2}{T_2}$. In this way any one of the six variables that might be missing may be quickly determined.

DETERMINATION OF CARBON IN STEEL

By Joseph McKenna, *Rindge Technical School*

The following demonstration is given to show the correlation between physics and chemistry and the application of scientific principles to the steel industry.

A one gram sample of steel is carefully weighed on the analytical balance, imbedded in crystal alumina, and then the combustion boat is placed in an electric furnace heated to a temperature of approximately 2000°F. Oxygen is now passed over the sample for 12 or 15 minutes or until oxidation is complete. The ascarite tower is now weighed and the increase recorded as carbon dioxide.

Weight of watch glass and sample	5.5461
Weight of watch glass	4.5455
Weight of sample	1.0006
Final weight of ascarite tower	93.9782
Initial weight of ascarite tower	93.9500
Weight of carbon dioxide	.0282

Calculation

$$\frac{12}{44}\times\text{wt. of } CO_2=\text{wt. of C}$$

$$\frac{\text{Wt. of carbon}}{\text{Wt. of sample}}\times 100=\%\text{ of C}$$

$$\frac{12}{44} \times .0282 = .00769$$

$$\frac{.00769}{1.0006} \times 100 = .7685\% \text{ C}$$

Bureau of standards = .765%
Error .0035%

BUSINESS MEETING

Mrs. Faith Hill of the Dana Hall School, Wellesley, Mass., and Mr. Theodore Sargent of the Swampscott, Mass., High School were elected active members.

Mr. Everett Learnard of the Norwood, Mass. High School and Mrs. Roberta Poland of Abbot Academy, Andover, Mass., were elected associate members.

It was voted that we express our thanks and appreciation to the Cambridge school authorities, Mr. Wood, and members of the Rindge Technical School faculty for their assistance in making our 135th meeting so successful.

REPORT OF COMMITTEE ON COLLEGE ENTRANCE REQUIREMENTS

Mr. B. L. CUSHING, *Chairman*

The following requirement in physics has been planned so as to be equally suitable for the instruction of the student preparing for college and for the student not going beyond the secondary school.

A standard textbook should be studied for the purpose of obtaining a connected and comprehensive view of the subject. The student should be given opportunity and encouragement to consult other books and periodicals. Especial emphasis should be placed upon lecture demonstrations to to illustrate the facts and phenomena of physics in their qualitative aspects and in practical applications.

The student should be taught to apply physical principles intelligently to the solution of simple and practical problems. No problems will appear on examinations which require absolute system of units or the transfer from one system of weights, measures or temperatures to another. When physical constants are needed for the solution of problems, they will be provided on the paper. Topics preceded by the symbol (*) in the syllabus should be treated quantitatively but no problem work will be required on other topics.

Laboratory work shall be as outlined in the previous C. E. E. B. Definition of Requirements.

The following syllabus constitutes a minimum list of fundamental topics which should be included in every well-planned course in elementary physics. These concepts and laws should be constantly illustrated throughout the course by reference to modern machinery and appliances which release and utilize energy.

SYLLABUS

(Topics preceded by the symbol (*) should be treated quantitatively but no problem work will be required on other topics.

Topics preceded by the letter (C) are considered common ground of both physics and chemistry.)

Introduction

C*Metric System, including millimeters, centimeters, meters, kilometers and corresponding units of weight and volume.

Mechanics

Fluids

*Laws of Liquid Pressure
*Pascal's Law
*Archimedes' Principle
C*Density and Specific Gravity
C*Boyle's Law
C*Atmospheric Pressure

Solids

*Simple Machines
*Mechanical Advantage
*Principle of Moments
*Center of Gravity
*Force, *Work, *Power, and *Energy
*Principle of Work applied to Machines
*Friction *Efficiency
*Composition and Resolution of Forces
*Accelerated Motion (initial or final velocity zero)
*Falling bodies
Gravitation Mass and Weight
Newton's Three Laws of Motion

Heat

C Fahrenheit, Centigrade and Kelvin or Absolute Scales of Temperature
Expansion of Solids and Liquids when heated
C*Expansion of Gases when heated. Law of Charles
Conduction, Convection, Radiation
C*Heat Units, British and Metric
C*Specific Heat
C Melting. *Heat of Fusion
C Evaporation and Boiling. *Heat of Vaporization
C Dew Point. Relative Humidity
*Mechanical Equivalent of Heat

Magnetism

Magnetic Attraction and Repulsion
Magnetic Induction
Terrestrial Magnetism

Static Electricity

C Electrical Attraction and Repulsion
Induced Charges
C Electroscope Condenser

Current Electricity

C Primary and Storage Cells
Electro-magnetism
C*Electrical Units and Measuring Instruments
*Ohm's Law
*Series and Parallel Circuits

C*Heating and Lighting Effects of Electricity
C Chemical Effects of Electricity
Induced Currents
Direct and Alternating Current Transmission

Sound

Creation and Propagation of Sound Waves
*Velocity in Air
*Relation between Velocity, Frequency and Wave Length
Pitch, Loudness and Quality
Reenforcement and Interference of Sound Waves

Light

A Method of finding the Velocity of Light
*Photometry
*Intensity of Illumination
Plane Mirror. Laws of Reflection
Convex and Concave Mirror Images
*Index of Refraction
*Convex Lens. Images
Concave Lens
C Dispersion. Color. Spectrum Analysis
C The Invisible Spectrum

Theories

The following theories should be taught and the evidence on which they rest should be understood
C The Kinetic-Molecular Theory of Matter
C Theory of Conservation of Energy
Wave Theory of Sound and Light
Magnetic-Molecular Theory
C Theory to account for the Flow of Electricity in a Solid, in the Solution of an Electrolyte and in a Radio Tube

Optional Topics

Candidates should be able to discuss intelligently the scientific principles involved in some of the modern scientific discoveries and inventions which are commonly presented in elementary physics textbooks.

Such might include the airplane, artificial refrigeration, x-rays, sound motion pictures and radio. One required question on the examination paper will present a list of such topics from which the candidate will be expected to choose one on which he will write a well-organized exposition illustrated, if possible, by sketches.

It was voted that the Association approve the above report and that it be forwarded to the College Entrance Examination Board.

REPORT OF COMMITTEE ON NEW BOOKS AND MAGAZINE LITERATURE

Mr. CARL W. STAPLES, *Chairman, Chelsea High School*
Mr. KENNETH L. GODING, *Attleboro High School*
Mr. THOMAS C. BAILEY, *Hartford Public High School*

NEW BOOKS

Electricity, by W. L. Bragg. Macmillan Co., Publishers, $4.00. 268 pages and index. 137 pictures and diagrams. A good book for boys and girls, as it uses mathematics sparingly. It uses the most common technical terms which are fully defined and explained.

The World Around Us. A modern guide to physics, by Paul Karlson. Simon & Shuster, Publishers. 293 pages. Very readable, and can be recommended to anyone, and especially to a beginning student of physics.

The British Journal Photographic Almanac. London. Henry Greenwood & Co. 716 pp. Illustrated. 2s net. (3s cloth binding.) Contains 8 special articles on special subjects in photography, as polarized light, etc. 64 pages of photogravure.

Silver, Its Properties and Industrial Uses. National Bureau of Standards Circular C412. Obtainable from Supt. of Documents, Washington, D. C. Price, 10 cents.

Peary, by William Herbert Hobbs. A biography. $5.00.

Electronics and Electron Tubes, by E. D. McArthur. John Wiley and Sons, Inc., New York. 173 pp. Illustrated. $2.50.

Electron Tubes in Industry. 2nd Edition, by Keith, Henney McGraw-Hill Book Co., New York. 539 pp. Illustrated. $5.00.

The March of Science. A First Quinquennial Review. 1931–1935. by Various Authors. Sir Isaac Pitman & Sons, Ltd. 1937. 3s 6d net.

Preparation of Scientific and Technical Papers, by Prof. Sam F. Trelease and Emma Sarepta Yule. 3rd Edition. 125 pp. Williams and Wilkins Co., Baltimore, Maryland. Bailliere, Tindel, & Cox, London. 7s.

Nuclear Physics, by F. Rasetti. Illustrated. 327 pp. $4.50. Prentice, Hall, Publishers.

The Concept of Time, by L. R. Heath. XIV+236 pp. $3.00. University of Chicago. A history of changing forms of the concept of time from ancient to present.

The Romance of the Calendar, by P. W. Willson. VIII+351 pp. Norton, Publisher. Origins, reformations, and conflicts in the calendar back to 7000 B.C.

The History of the Discovery of Photography, by George Potoniee. Translated by Edward Epstean. X+272 pp. $8.00. Tennant & Ward, Publishers.

MAGAZINE LITERATURE

Air Conditioning

"Air Conditioning a Windowless Building." Illustrated. *Sheet Metal Worker*, February, 1937, pp. 34–40.

"Air Conditioning a Poultry-House." *Sheet Metal Worker*. February, 1937, p. 52.

"Air Conditioning." *Science*, 85: sup. 7, January 29, 1937.

"New Air Conditioner Becomes Plug-in Appliance." *Scientific American* (156), March, 1937.

"Pasteurized Air," (humidity, noise, winter, summer, controlled by air-conditioning). *Literary Digest* (123), pp. 19–21, February 20, 1937.

Alloys

"A Brief Chronicle of the Alloy Year." *Sheet Metal Worker*, February, 1937, p. 29.

"A Large Manufacturer of Nickel Silver, Phosphor Bronze, and Nickel Anodes." (A description of the products, plant and manufacturing methods of the Seymour Manufacturing Co., Seymour, Conn. A sketch of the history and uses of nickel-silver and phosphor bronze.) *Metal Industry*, February, 1937, pp. 51–6. Illustrated.

Astrophysics

"Observing an Eclipse in Asiatic Russia," by Irvine C. Gardner. 19 Illustrations. *National Geographic Magazine*, February, 1937, pp. 178–9.

"Determining the Composition of the Stars." Condensed from a lecture by Sir Arthur Eddington. *Science Digest*, March, 1937, pp. 90–4. (The *Science Digest* first appeared in January, 1937.)

"The 26 Moons" (condensed from "The Sky"), by Arthur L. Draper. *Science Digest*, March, 1937, pp. 21–3.

"Sunspots and Police Calls; Short wave radio frequently heard across the Atlantic." *Science* 85, sup. 7, February 12, 1937.

"Sunspots and Radio." *Time* (29), pp. 53–4, February 15, 1937.

Atomic Physics

"Smashing Atoms." *Popular Mechanics* (67), pp. 321–5, March, 1937.

"The Electron; its Intellectual and Social Significance," by K. T. Compton. *Science* 85, pp. 27–37, January 8, 1937.

Aviation

"The Next 5 Years in Aviation," by A. Klemin. *Scientific American* (156), p. 183, March, 1937.

"How to Make Flying Safe," by K. B. Collings. *American Mercury* (40), pp. 151–7, February, 1937.

"U. S. Aerial Progress on Parade." *Literary Digest* (123), pp. 30–1, January 30, 1937.

"Rise of Air Transportation," by R. M. Cleveland. (With maps and tables.) *Scientific American* (156–80), February, 1937.

"What's Ahead for Aviation?" by Sikorsky. *Vital Speeches* (3), pp. 212–13, January 15, 1937.

"More Super-Planes." *Business Week*, p. 14, February 27, 1937.

"Col. Lindbergh's Latest Plane, the Miles Mohawk," by A. Klemin. (With diagrams.) *Scientific American* (156), p. 178, March, 1937.

"Time Flies, New Ship Designed and built by Frank Hawkes, and Howard Miller," by A. Klemin. *Scientific American* (156), p. 106, February, 1937.

"The Instrument of Blind Flying" (condensed from *Tech. Eng. News*), by Charles S. Draper. *Science Digest*, pp. 55–9.

Biophysics

"Physics in the Attack on the Fundamental Problems of Genetics," by Dr. H. J. Muller. *The Scientific Monthly*, March, 1937, pp. 210–14.

Diesel Engines

"The Diesel." *Scientific American* (156), p. 72, February, 1937.

Electricity

"Fields Caused by Remote Thunderstorms," by K. E. Gould. *Bell Laboratories Record*, March, 1937, pp. 221–4.

Fluorescence

"Fluorescence—an Unexplained Phenomenon" (condensed from *The Pennsylvania Triangle*), by Charles A. Dahlke. *Science Digest*, pp. 53–4, March, 1937.

Friction

"Non-Spreading Lubricating Oils," by W. E. Campbell. *Bell Laboratories Record*, January, 1937, pp. 149–53.

Gases

"Producing Liquid Helium," by Dr. H. C. Dickinson. *Science Digest*, March, 1937, pp. 83–5.

Geophysics

"The Earth's Interior. Its Nature and Composition," by Dr. Leason H. Adams. *Scientific Monthly*, March, 1937, pp. 199–209.

"Crater Lake and Yosemite Through the Ages," by Wallace W. Atwood, Jr. With 13 paintings by Eugene Kingman. *National Geographic Magazine*, March, 1937, pp. 327–38.

"Exploring the Ocean Depths" (condensed from a Science Service Radio Talk). *Science Digest*, March, 1937, pp. 71–4.

Historical Physics

"The Steamer *J. T. Morse*, Her History and Adventures," by Joseph Allen, Jr. Illustrated. (Last side-wheeler of her size to be built in New England for combined passenger and freight.) *Old Time New England*, January, 1937, pp. 79–98.

"William Claggett of Newport, R. I., Clockmaker," by Albert L. Partridge. Illustrated. *Old Time New England*, January, 1937, pp. 110–15.

"The Leipzig Technical Fair, Promoter of International Trade." *Engineering Progress*, January, 1937, pp. 13–15.

"The Trail of the Miner's Candlestick," by Ruby T. Scott. *Antiques*, March, 1937, pp. 122–3.

"Seeing Solid. The Third Dimension at Work and Play," by John J. Rowlands and J. Rhyne Killian, Jr. *Technology Review*, March, 1937, pp. 191–5.

"Talking Battery," by R. P. Martin, Jr. *Bell Laboratories Record*, January, 1937, pp. 138–44.

Hydraulics

"Fifty Foot by Fifty Foot Bulkhead Gates at Boulder Dam," by P. A. Kinzie (2nd article). *Engineering*, February 5, 1937, pp. 139–42.

"Le Barrage du Sautet." *L'Illustration*, January 2, 1937, pp. 8–11.

"Eine Grosstat Deutscher Technik. Das erste Unterwasserkraftwerk der Welt in Rostin (Pommern)—wurde kürzlich in Betrieb genommen." *Illustrierte Zeitung* (Leipzig), January 30, 1937, p. 115.

Industrial Physics

"The Position of Electrical Industries in Japan," by P. N. Ghosh. *Calcutta Review*, November, 1936, pp. 212–18.

Invisible Radiations

"New 1,200,000 Volt X-ray Machine Aids Cancer Fight." *Science News Letter*, January 23, 1937, p. 53. Claimed to be newest aid in science in the fight on cancer. Shown at Columbia University's Institute for Cancer Research.

"Bacteria Blocked with Ultraviolet-Ray Screen." *News Week* (9), p. 38, January 23, 1937.

"New High Voltage X-Ray Plant for Research and the Treatment of Cancer," by F. C. Wood (with diagrams). *Scientific Monthly* (44), pp. 280–7, March, 1937.

"Giant X-ray Machines, Science's Siege Guns in War on Disease," by J. E. Dodge (diagrams). *Popular Science*, (130), pp. 27–9.

"X-raying a Mummy." "Bulletin, National Museum of Art." *Science Digest*, March, 1937, p. 23.

Luminescence

"Luminescence, Its Mechanism and Applications to Lamps, Signs, and Cathode Ray Tubes." Interior Lighting Possibilities. *The Electrician*, February 5, 1937, p. 183.

Magnetism

"Some Pull! Newly Developed High Field Strength Magnet." *Scientific American* (156), March, 1937, p. 202.

Meteorology

"Ice from the Clouds" (condensed from *Natural History*), by Charles Titzhugh Talman. *Science Digest*, March, 1937, pp. 63–6.

Microscopy

"Can Cancer be Cured?" "New Electron Microscope May Hold Secret," by Margaret Seator. *Germany and You*, March, 1937, p. 13,

"A Metallographic Microscope of Exceptional Power," by F. F. Lucas. *Bell Laboratories Record*, December, 1936, pp. 103–7.

Mining

"Ein Bergwerk im Keller. Unter der Technischen Hochschule Charlottenburg." *Daheim*, January, 1937.

Miscellaneous

"Machines that aid the Doctor" (condensed from *Hygeia*), by Frank H. Kruser. *Science Digest*, pp. 37–60.

Optics

"Building the World's Largest Telescope," by D. Pryse-Jones. Illustrated. *Travel*, February, 1937, pp. 36–40.

"Einstein Invents Automatic Camera with Electric Eye." *Science News Letter*, December 5, 1936, p. 362.

Philosophy

"Le reel et la science," by Jean Ullmo. *Revue Philosophique*, Nov.–Dec., 1936, dinne.

Photography

"Photography in Criminology, Homicide, and Suicide," by L. A. Waters. *American Photography* (31), pp. 153–62, March, 1937.

"Enlarge, Print, Retouch; Details of a Vertical Enlarger," by H. E. Hayden (diagrams). *Scientific American*, March, 1937 (156), pp. 170–3.

"Photography by Polarized Light," by J. W. McFarlane. *American Photography*, March, 1937 (31), pp. 208–9.

Radio

"Norddeich der Sender der Seeleute." *Daheim*, January 28, 1937, pp. 16–18. Illustrated.

"A Half-Meter Tube," by C. E. Fay. *Bell Laboratories Record*, February, 1937, pp. 178–81.

"Harnessing Radio's Baby Waves." *Popular Mechanics*, March, 1937 (67), pp. 370–2.

"New International Radio Service for Broadcasting Cosmic Data." *Scientific Monthly*, March, 1937 (44), pp. 288–9.

"Around-the-World Radio Echoes," illustrated by A. C. Peterson, Jr. *Bell Laboratories Record*, March, 1937, pp. 216–20.

"Thirty-seven Tube Receiver." *Popular Mechanics*, March, 1937 (67), p. 417.

"The 313A Vacuum Tube," by S. B. Ingram. *Bell Laboratories Record*, December, 1936, pp. 114–16.

Radioactivity

"Radium Enters Industry." *Review of Reviews*, December, 1936, pp. 38–9.

Reading Lists

"A Reference List of Important Publications Dealing with Heating and Air Conditioning." *Heating and Ventilation*, February, 1937, pp. 42–4.

Statistical Method

"Four in a Series of M. I. T. Library Reading Lists," compiled by Margaret-Paige Hazen. *Technology Review*, December, 1936, pp. 77–8.

"The Philosophy of Science," fifth in series. January 1937, p. 112.

Reviews of Past Year

"Science and American Literature," by Paul C. Eaton and Frederick G. Fassett, Jr. *Technology Review*, February, 1937, p. 153.

"The March of Science in '36" (condensed from a Science Service Radio Talk). *Science Digest*, March, 1937, pp. 32–6.

"The Progress of Science." Illustrated. *The Scientific Monthly*, March, 1937, pp. 284–94.

"The Case for Nazi Science," by Hans E. Friedrich. Translated from *Deutsche Allgemeine Zeitung*. *The Living Age*, March, 1937, p. 22.

"Research Parade," a preview of science's aid to industry. *Science News Letter*, December 5, 1936, p. 356. (Discussion of direct current transmission, solar power, polarized light, glass, lignin, electron image tube, etc.)

"Science Strides Onward in 1936." *Science News Letter*, December 26, 1936, p. 403. (A fine summary of the outstanding 1936 achievements in ten fields of science. Includes Aeronautics, Archaeology, Astronomy, Biology, Chemistry, Engineering, Earth Sciences, Medicine, Physics, and Psychology.)

"Scientific Events of the Year." *Science* (85), sup. 8, January 1, 1937 and *Science* (85), sup. 8, January 8, 1937.

Sound

"Synthesizing Speech," by Homer Dudley. *Bell Laboratories Record*, December, 1936, pp. 98–102.

"Pipeless Instruments Pipe Hammond Clock out of Red." *News Week* (9), February 13, 1937, p. 28.

"Sound Reinforcing System for Hollywood's Bowl," by A. R. Soffel. *Bell Laboratories Record*, March, 1937, pp. 225–8.

"A Modernized Hearing Meter," by R. Nordenswan. *Bell Laboratories Record*, January, 1937, pp. 163–6.

"Decibel Meters," by F. H. Best. *Bell Laboratories Record*, January, 1937, pp. 167–9.

"How Pitch Changes with Loudness," by A. R. Soffel. *Bell Laboratories Record*, pp. 145–8.

"The Romance of Bells," by John Macnau Reid. *Chambers Journal*, December, 1936, pp. 934–5.

"Science Attacks Noise" (condensed from *Refrigerating Engineer*), by Walter J. Hodge. *Science Digest*, March, 1937, pp. 12–16.

Stratosphere

"Chemical Exploration of the Stratosphere," by Prof. F. A. Paneth.

"Charts, Illustrations, Bibliography." *Nature*, February 6, 1937, pp. 220–3.

"First Color Photograph from the Stratosphere," by Albert W. Stevens. *National Geographic Magazine*, March, 1937, p. 340.

Testing

"Impact Tests for Organic Finishes." *Bell Laboratories Record*, December, 1936, pp. 108–10.

"Testing the Driver's Skill" (condensed from *Instruments Magazine*), by Harry R. DeSilva. *Science Digest.*

Time

"Nouvelles Inventions"—"Pendule Electrique Perfectionnee." *L'Illustration*, December 19, 1936.

Transportation

"Electrons Drive the Wheels" (General Electric's part in the transportation advance), by A. Pound. *Atlantic Monthly* (159), March, 1937, pp. 377–84,

"Automobiles that Fly," by Malcolm B. Ronald. *Atlantic Monthly*, January, 1937, pp. 20–7.

REPORT OF THE COMMITTEE ON CURRENT EVENTS

MR. JOHN B. MERRILL, *East Boston High School, Chairman*

Streamlined Steam Locomotive

The N.Y.H. & H.R.R. has had on exhibition the first of ten new streamlined steam locomotives to be placed in passenger service between Boston and New York in the near future. These are equipped with all sorts of the most modern devices for economy and safety, and are well worth the attention of every physicist. They represent the latest answer of steam to the bid being made by the Diesel engine and other forms of power for supremacy in the transportation field.

Longer Rails for Smoother Rides

The American Society of Civil Engineers announced the use of new rails a mile and a half long at River Valley, Pa. Others exceeding a mile by 700 feet are in service at Mechanicville, N. Y., by the Delaware and Hudson. These rails are made by welding the ordinary 39 foot lengths together. A half mile of these are said to have an expansion range of only $\frac{3}{4}$ of an inch.

Wall of Invisible Light to Restrain "Flu" Germs

Wm. R. and M. W. Wells have developed a system of flooding a space 1000 cu. ft. in size with ultraviolet light in an attempt to kill disease germs in a hospital corridor at the Children's Hospital in Boston.

Still Another "Flu" Remedy

The Rockefeller Institute for Medical Research reports trying a vaccine on thirty humans. Favorable results followed all of the trials, and there were no ill effects. The blood of the patients was protected by natural protective agencies.

Short Wave Rading

Dr. R. S. Richardson of the Mt. Wilson Observatory reports that this is apparently caused by an unknown ray from the sun.

New International Broadcasting Service

On February 1, Station W1XAL inaugurated a daily broadcast of cosmic data and scientific news.

Unique Broadcast Permit

Station W3XFE has the only Federal permit to broadcast continuously on all frequencies. It is used to study the earth's ionosphere.

Drought Machine

Drs. Burton E. Livingstone and W. L. Norem of Johns Hopkins University have invented a "Drought Machine" which can be used to determine when garden plants are likely to wilt, even before the process is discernible.

Einstein's Camera

Einstein has patented a camera with a photoelectric cell which automatically determines and sets the correct aperture and exposure time.

Lightning

Man-made lightning produced by K. B. McEachron at the General Electric High Voltage Laboratory has employed 12,500,000 KW (approximately equal to the average output of all utility supply stations at the present time). At 5,000,000 volts a current of 50,000 amperes flowed, the highest ever obtained at this voltage.

Lightning strikes not twice but a dozen times in the same place over the same path within one second's time.

A lightning flash is not a bolt from the sky, but the union of a cloud streamer with a similar one from the earth. "Action of the air currents and of the falling drops of water separates the charges in the cloud. When voltage in cloud reaches a certain value, a streamer starts toward the earth, travelling in jumps at about one tenth the speed of light. When this streamer is a few hundred feet away, streamers from four to eight feet long begin to form on earth. When streamer from clouds unites with one from earth, the flash occurs."—(*Tech. Eng. News*)

New Comet

A. Wilk, with headquarters in Cracow, Poland, has discovered a new comet in the western sky. The same has been observed by Leland Cunningham of the Harvard Observatory.

Phonographic Love Call

A phonograph record of the "love cry" of a lady orang-utan has been shipped to the jungles of Sumatra, where it will be used in an effort to capture the "boy-friend." This was explained by Wm. Blackburne, head keeper of the Washington Zoo.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1476. *Charles Koren, Bayonne, N. J.*

1488, 80. *Daniel Finkel, New York City.*

1479. *Daniel Finkel, New York City, James V. Bernardo, Plainville, Connecticut.*

1482, 3. *Charles W. Trigg, Charles Koren.*

1486, 7. *Bert Fowler, Centralia, Ill., George W. Haas, Lakefield, Minn.*

1486. *M. Hyams Washam, Sherman, Texas.*

1478, 9, 1450–86. *G. S. N. Ayyar.*

1484. *Thomas A. Pickett, Boston.*

1490. *Proposed by Arthur L. Hill, Peru, Nebr.*

One of two barber shops in a small town charges 25 cents for a hair-cut and ten cents for a shave. The other shop charges 20 cents for a hair-cut and 15 cents for a shave. Seeing the opportunity to save 5 cents a man gets a 20-cent hair-cut in the second shop and a 10-cent shave in the first shop. How is this saving distributed between the two shops?

Solution by Hyman Marcus, New York City.

In the first shop mentioned the man saves 5¢ on the shave. In the second shop he saves 5¢ on the hair-cut. The ratio of the saving due to the prices in shop one to shop two is 5/15:5/25 or 5:3. Hence in the first shop the saving was $\frac{3}{8}$ of $5¢ = 3\frac{1}{8}¢$, while in the second shop the saving was $\frac{5}{8}$ of $5¢ = 1\frac{7}{8}¢$.

A similar solution to this problem of doubtful meaning was offered by G. S. N. Ayyar.

1491. *Proposed by Collis Bardin, Fresno, Calif.*

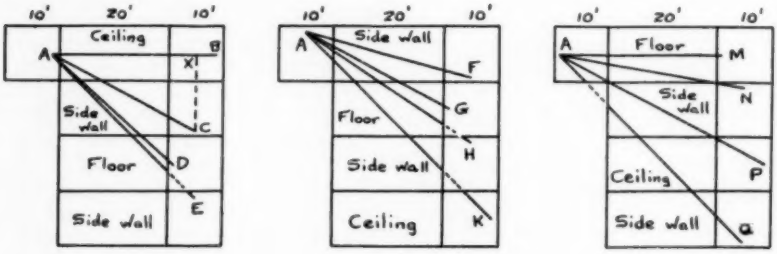
A room is 20′ by 10′ by 10′. On one of the 10′ by 10′ end walls, midway from the sides, and one foot from the ceiling a spider walks along the surfaces of the room, floor and ceiling included, to a fly which stood on the opposite end, midway from the sides but one foot from the floor. What is the length of the shortest path by which the spider can reach the fly? What are the angles of intersection of the path with the edges of the room? Is there more than one path shorter than 30 ft.?

Solution by Charles W. Trigg, Cumnock College, Los Angeles.

In order to calculate the lengths of the various "straight line" paths by which the spider leaving A may reach the fly at a point $(B, \cdots, Q)$ on the other end wall, imagine the walls, ceiling and floor to be folded down into a plane in all possible ways. Then the lengths of the various paths may be calculated by the Pythagorean thorem. Obviously, paths AE, AH, AK and AQ are discontinuous, so are not to be considered. Of the other paths,

$$AB = AM = 1 + 20 + 9 = 30 \text{ feet},$$
$$AC = AG = \sqrt{26^2 + 14^2} = 29.5296461 \text{ feet},$$
$$AD = \sqrt{22^2 + 20^2} = 29.7321375 \text{ feet},$$
$$AF = \sqrt{30^2 + 8^2} = 31.0483494 \text{ feet},$$
$$AN = \sqrt{34^2 + 6^2} = 34.525353 \text{ feet},$$
$$AP = \sqrt{38^2 + 20^2} = 42.941821 \text{ feet}.$$

In calculating these distances, the room measurements have been assumed to be exact.



Since these constitute all the possible "straight line" routes in which no surface is encountered more than once, it is evident that route $AC = AG$ is the shortest. The spider could have left the ceiling or the end wall by either side wall, so a route of length equal to AC may be chosen in 4 ways. Evidently path AD could have been accomplished via either side wall, so there are 6 "straight line" paths less than 30 feet. But the spider could vary from any of these routes by a very small amount in an infinity of ways and still not exceed 30 feet. Hence, strictly speaking, there are an infinity of routes shorter than 30 feet.

The angles of intersection of the shortest path with the edges of the room are precisely equal to the acute angles of the right triangle AXC, by which the length of the path was calculated, that is, $\tan^{-1}\frac{14}{26} = 28°18'3''$ and $\tan^{-1}\frac{26}{24} = 61°41'57''$.

Solutions were also offered by G. S. N. Ayyar, Tiruvilwamala, India, J. E. Dinger, Kahoka, Mo., Hyman Marcus, New York City, W. R. Smith, Chicago, Jack Demsey, Wilmington, Calif., and the proposer.

1492. *Proposed by G. S. N. Ayyar, India.*

A pulley wheel of 12 inch radius is driven from a pulley wheel of radius 4 inches by a band 8 ft. long passed around the pulleys without crossing. Calculate the distance between the centers of the wheels.

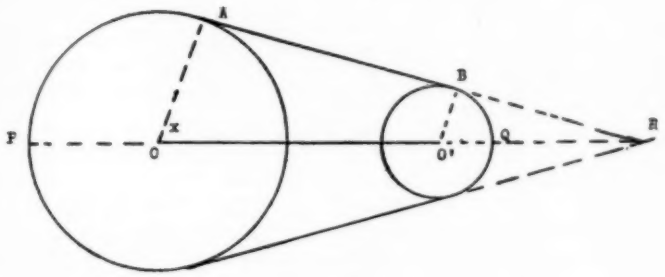
Solution by Clyde A. Bridger, Mackay, Idaho.

From Plane Geometry we have OA and $O'B$ perpendicular to AB. Produce AB and OO' to meet in R. Let angle $AOR = x$ and be measured in *radians*. The distance half way along the band is arc PA + tangent AB + arc $BQ = 48$ inches.

In right triangles AOR and $BO'R$, we have $AR = 12 \tan x$ and $BR = 4 \tan x$. Hence $AB = 8 \tan x$.

Substituting equals for equals in the above equation, we have $8 \tan x + 12(\pi - x) + 4x = 48$. This will yield x. By using the same triangles, we find that $OO' = 8 \sec x$.

(First approximation to correct solution.)



$\tan x - x = 6 - (3/2)\pi$, or $\tan x = x + 1.2876$.

An examination of a table of trigonometric functions based on radian measure shows that the first approximation to the correct value of "x" is $x = 1.19$ radians.

Then, the distance between the centers is $OO' = 8 \sec 1.19$ or *about 21.5 inches.*

Solutions were also offered by Hyman Marcus, Charles Trigg, Thomas J. Johnson, Torrington, Conn., and the proposer.

1493. *Proposed by Mr. Ayyar.*

If n is any number other than a perfect square, and if a is the difference between n and the next larger square and b the difference between n and the next smaller square, then $n - ab$ is a perfect square.

Solution by H. R. Mutch, Glen Rock, Pennsylvania.

We have, as the conditions of the problem,

$$n + a = (s+1)^2$$
$$n - b = s^2$$

whence,
$$a = (s+1)^2 - n$$
$$b = n - s^2$$

and,
$$ab = n(s+1)^2 - n^2 + ns^2 - s^2(s+1)^2.$$

Finally,
$$\begin{aligned} n - ab &= n - n(s+1)^2 + n^2 - ns^2 + s^2(s+1)^2 \\ &= n^2 - n[1 - (s+1)^2 - s^2] + s^2(s+1)^2 \\ &= n^2 - 2ns(s+1) + s^2(s+1)^2 \\ &= [n - s(s+1)]^2, \text{ which was to be proved.} \end{aligned}$$

NOTE: Charles W. Trigg and Aaron Buchman point out that if a and b are signed numbers, n may be any rational numbers.

Other solutions were offered by Clyde A. Bridger, Mackay, Idaho, B. H. Phipps, Hyman Marcus, New York City, A. R. Haynes, Bert Fowler, Centralia, Ill., David Rappaport, Chicago, David J. Cohen Brooklyn, and the proposer.

1494. *Proposed by Seymour J. Sherman, New York City.*

A circle centre, O, is circumscribed about a triangle ABC, with BP and CP tangent to the circle at B and C respectively. If A' is the midpoint of BC, show that $CAA' = PAB$.

First Solution.

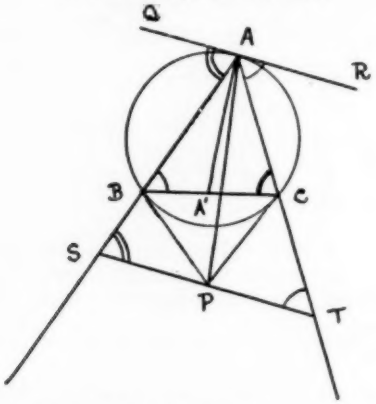
By G. S. N. Ayyar, *Tiruvilwamala, India.*

Draw the intercept SPT, parallel to the tangent QAR at A, S being in AB produced and T in AC produced.

Then $\angle CAR = \angle ABC$. Also $\angle CAR = \angle CTS$. Hence $\angle ABC = \angle CTS$.

Similarly, $\angle ACB = \angle BST$.

$\therefore$ TS is anti-parallel to BC.



Also P bisects ST; for $PS = PB = PC = PT$.

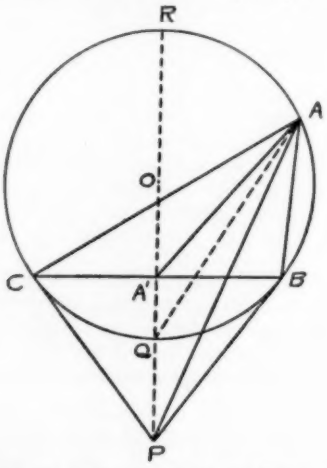
Hence AP is the symmedian of the triangle ABC, and AA' is the median.

Hence $\angle CAA' = \angle PAB$.

Second Solution

By Charles W. Trigg

Draw PO cutting the circle at Q and extend it to cut the circle again at R. PR is the perpendicular bisector of CB, so passes through A'. BC is



the polar of P with respect to the circle O, so the points R, Q, A', P constitute a harmonic range. As A is on the circumference of the circle with RQ as diameter, it follows that $AA' : AP :: A'Q : QP$. Hence AQ is the bi-

sector of angle $A'AP$. But Q is the intersection of the perpendicular bisector of CB with the circumcircle of the triangle, so AQ bisects angle CAB. It follows that $\angle CAA' = \angle PAB$ and $\angle PAC = \angle BAA'$.

Solutions were also offered by A. R. Haynes, Hyman Marcus, New York City, Aaron Buchman, Buffalo, and the proposer.

1495. *Proposed by Robert Crookshank, Brookfield, Mo.*

If a street 40 ft. wide ends in a perpendicular cross street 35 ft. wide, what is the length of the largest girder which can be taken around the corner if the girder is always in a plane parallel to the plane of the streets.

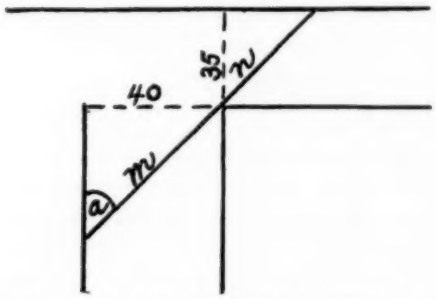
Solution by J. Slavin, Brooklyn.

Let length of girder $= L = m + n$.

Hence $L = 40 \csc a + 35 \sec a$. To find a maximum, obtain $dL/da = -40 \csc a \cot a + 35 \sec a \tan a$.

Set $dL/da = 0$, we obtain $\tan a = \sqrt{8/7}$, from which $a = 46°16'30''$.

This gives $L = 106$ (approx.) if no allowance is made for the width of the girder.



Solutions were also offered by Charles W. Trigg, Los Angeles, H. R. Mutch, Glen Rock, Pa., G. S. N. Ayyar, India, Hyman Marcus, V. C. Bailey, Emory, Va., and W. R. Smith, Chicago.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1486, 1487. *G. Watson, John R. Whyte, and Colin LaZier, Upper Canada College, Toronto.*

1491. *John R. Whyte and A. G. Watson, Upper Canada College, Toronto, Bert Fowler, Centralia, Ill., Durwood Newall and Paul Lee, Perry (Iowa) H. S.*

1493. *Harold H. Sogin, Tilden Tech. H. S., Chicago.*

PROBLEMS FOR SOLUTION

1508. *Proposed by Robert Crookshank, Brookfield, Missouri.*

An upright flag pole was broken and fell across a building, in the shape of a cube 10 feet on a side. It fell so that the broken part rests on the edge

of the building, and the end of the pole rests on the ground. If the building stands next to the upright portion of the flag pole, find the height of this part of the pole.

1509. *Proposed by Marquess Wallace, Mexico, Mo.*

Two trains on parallel tracks, one running at the rate of 30 miles per hour and the other at the rate of 45 miles per hour, pass each other in 4 seconds when they are traveling in opposite directions. When traveling in the same direction, they pass each other in 80 seconds. Find the lengths of the two trains.

1510. *Proposed by Neil Little, Purdue University.*

Find the moment of inertia of the area of a rectangle, dimensions b and h, with respect to a line through the centroid which makes an angle of Q with the base of the rectangle.

1511. *Proposed by D. A. Wallace, St. Paul.*

Prove by a method other than the one usually given in textbooks, that the side of a regular inscribed pentagon is $R/2\sqrt{10-2\sqrt{5}}$, where R is the radius.

1512. *Proposed by G. V. Cox, Warren, Ill.*

In a triangle APQ, A is a fixed point while P moves in a fixed line CD; AP meets a fixed line TW parallel to CD in R; angle APQ is fixed and $AR=PQ$. Show that Q lies in a straight line.

1513. *Proposed by George W. Haas, Lakefield (Minn.) High School.*

Find two numbers such that their sum added to their product is 47, while their sum subtracted from the sum of their squares is 62.

SCIENCE QUESTIONS

June, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

This department is a forum for discussing Texts, Experiments, Pedagogical Questions, Scientific Happenings. Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific). Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, Any Problem or Question that will help teachers make Science Teaching interesting.

The discussion usually takes the Question and Answer Form. Readers, whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.

As a Mode of Recognizing contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and more than 180 contributors have already been admitted to Membership. Classes or individuals, may become members by proposing a question or submitting an answer.

JOIN THE GQRA

GQRA—NEW MEMBERS, JUNE, 1937

175. Professor T. A. A. Broadbent, M.A., Editor: Mathematical Gazette, 62, Coleraine Road, Blackheath, London, SE, 3.
176. W. R. Smith, Lewis Institute, Chicago, Ill.
177. George Shugart, Marion College, Marion, Indiana.
178. Robert Arnold, R.F.D. #4, Sparta, Wisconsin.
179. Chris Wessel, Student, Valparaiso University, Valparaiso, Ind.
180. John De Haan, Instructor, Grand Rapids Christian High School, Grand Rapids, Mich.
181. Peter Brink, Student, Grand Rapids Christian High School.
182. Peter Paap, Student, Grand Rapids Christian High School.
183. Saylor C. Cubbage, Woodrow Wilson High School, Washington, D.C.
184. Roy C. Hatch, Silliman Laboratory, Mount Hermon School, Mt. Hermon, Mass.

QUIZ OF THE MONTH—THE HINDENBURG DISASTER

802. *From the Newspapers.*

Why did not the Hindenburg use helium gas and thus avoid this terrible disaster?
How much hydrogen gas did the Hindenburg carry?
How much did the ship weigh?
What pay load could it carry?
Why or why not take a Zeppelin to Europe? (Limit 10 lines)

LOOKING FORWARD

803. *What are you going to start this fall that is new, or unusual, or more interesting?*

What do pupils think of the science courses we are giving?
What can "Science Questions" do to be of greater use to a larger number of readers of SCHOOL SCIENCE & MATHEMATICS?

GQRA INFORMAL MEETING AND PICNIC

On Saturday and Sunday, July 31st and August 1st, the EDITOR will be at his summer home PEN'BRYN, Geneva, Ohio, RD 1. (1,200 feet east of Geneva Township Park on the Lake Shore Road—State Route 531) Follow US 20 to the center of Geneva. Turn north on Route 534, follow the signs to Route 531 and STOP AT PEN'BRYN.

You will find a few congenial souls and should be able to spend a few pleasant hours.

GREAT LAKES EXPOSITION AT CLEVELAND —JUNE 1 TO OCTOBER 1

Worth coming to—Give the Editor a ring at Cherry 1000, or Republic 0755 W. Addresses in telephone book.

ANHYDROUS AMMONIA AS MOTOR FUEL

804. *From Science News Letter of Oct. 10, 1936, contributed by W. F. Roecker (GQRA No. 15).*

"In search of motor fuels, Italy is finding unexpectedly good results with anhydrous ammonia."

Is there any probability that this statement rests on scientific fact? If so, what established knowledge of chemistry would support this statement?

SOME ANSWERS TO 763, 766 and 784

763. *Mechanics of a Flexible Rope—The American Physics Teacher by Professors W. W. Sleator, and Raymond T. Birge.*

Answer by Charles P. Louthan (GQRA No. 1460)—50 poundals.

766. *Submitted by "Interested," Newark, N. J.*

("Interested" is unknown by name. Please send in name and receive an election to the GQRA.)

The problem of the three poles, $-m$, $2m$, and $-m$, placed on the x-axis at distance -1, 0, and 1 from the origin.

Answer by Charles P. Louthan, Columbus, Ohio (GQRA No. 146).

"Total value of potential found exactly. The result given is an approximation, and after ten approximations is found to be true."

784. *Proposed by Frederick Wolter, student, Peru State Teachers College, Peru, Neb. (GQRA No. 159).*

If the coefficient of expansion of steel (1.2% C, from 0° to 100°C.) is taken as 10.5×10^{-6} and a steel bar has its end fixed so that expansion takes place in the form of the arc of a circle, find the distance the midpoint rises from the horizontal for a bar one mile long if the temperature increases 100° Centrigrade.

Answer by Charles P. Louthan (GQRA No. 146)—109.843 Ft.

"SEND MORE MONEY"—WHENCE CAME YOU?

791. *Answer from Jerome C. Forma, Augsburg College, Minneapolis, Minn. (GQRA No. 102).*

"The sum of $106.52 could be correct although Alexander Botts would have been just as well satisfied if they had sent him $10,652."

Professor T. A. A. Broadbent, Editor: Mathematical Gazette, London (Elected to the GQRA No. 175) says—

"See Gazette, XVII, No. 222, p. 24; evidently an old favorite."

W. R. Smith, Lewis Institute, Chicago (Elected to the GQRA No. 176) says—

"Appeared in the 'Kalends,' Williams & Wilkins' house organ, some time last year."

George Shugart, Marion College, Marion, Indiana (Elected to GQRA No. 177) says—

"I saw this problem in an edition by the Hood Rubber Mfg. Co. about six years ago. This edition was a pamphlet entitled '101 Brain Twisters.'"

(Maybe we'll find that the ultimate source was Shakespeare—Who knows.)

MAKE THE RIGHT CONNECTIONS

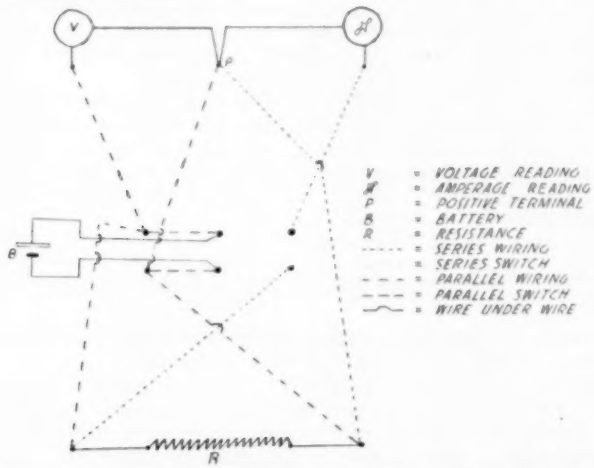
793. *Proposed by J. S. Urban (GQRA, No. 171), Cameron, Missouri.*

In my high school Physics course I use an adaptation of Experiment 48, in Krenerick's "Manual of Experiments and Projects in High School Physics." This is the familiar experiment for measuring resistance by the ammeter-voltmeter method except that he suggests a volt-ammeter instead of separate instruments. I use Cenco, three-button galvanometers with appropriate shunts. To save time we wish to connect galvanometer, battery and resistance to a double-throw, double-pole switch so that throwing the switch one way gives a voltmeter connected in parallel with the resistance and throwing the switch the other way gives an ammeter in series with the resistance. How can it be done?

Maybe the above problem is too trival for publication in "Science Questions," but I have never seen it in any book and it is a little hard to get the right slant on it.

Solution: By Robert Arnold, Student, Sparta High School, Sparta, Wisconsin. (Elected to the GQRA, No. 178.)

Connect the battery to the two center terminals of double-throw, double terminal switch. Connect wire to one outside terminal, of Series switch, directly to the terminal of the resistance, the current going through the resistance into a wire which leads to the positive (neutral) terminal of the volt-ammeter. The current passes through the volt-ammeter out of the ampere terminal into the wire connected to the other outside terminal of the series witch, making the circuit complete with the switch, resistance, and volt-ammeter in series.



For the parallel connection disregard the volt-ammeter at first. Connect the switch and resistance in parallel. Connect a wire to outside terminal, of the parallel switch, directly to terminal of resistance, the current passing through the resistance, and leaving it by a wire connected directly to other outside terminal, of the parallel switch. Then connect the positive (neutral) terminal to one of the outside terminal of the parallel switch, and the volt-meter terminal to the other outside terminal, of the parallel switch, making a complete parallel circuit.

There is no practical use of having the current passing through the voltmeter.

To prove that these connections were right I set up the apparatus with a telegraph sounder, resistance 4 ohms, took the voltage and amperage readings. I then substituted these values in Ohm's Law, the value of the resistance was 4 ohms.

793 was also solved by the following—

Jerome C. Forma, Minneapolis, Minn. (GQRA, No. 102).

Chris Wessel, Student, Valparaiso University, Valparaiso, Ind. (Elected to the GQRA, No. 179).

John De Haan, Instructor, Grand Rapids Christian High School, Grand Rapids, Mich. (Elected to the GQRA, No. 180).

Peter Brink, Student, Grand Rapids Christian High School (Elected to the GQRA, No. 181).

Peter Paap, student, same (Elected to the GQRA, No. 182).

Adrian Struyk, Paterson, N. J. (GQRA, No. 75).

J. S. Urban, Cameron High School (GQRA, No. 171).

(I regret that all the solutions and diagrams cannot be published—lack of space prevents. Editor.)

FREAKISH QUESTIONS

794. *Proposed by Robert E. McKay (GQRA, No.* **172**), *Middleport High School, Middleport, Ohio.*

Science teachers are quite often asked to settled an argument on some scientific question, or to explain some "freakish" phenomena on the basis of scientific laws. Recently I was approached by a man with one of these so called "freakish" problems. I had to stop and think for a few minutes before I could give a suitable explanation. Perhaps some of the readers would like to bring it before their physics classes.

On one very cold evening this winter this man had taken two bottles of pop from his kitchen window where they had been for a number of days. One bottle had frozen solid. The other was a liquid, so he decided to drink it. He uncapped it and raised it to his mouth, but as he did so, the contents became a solid mass.

Explain that!

Solution by Saylor C. Cubbage, Woodrow Wilson High School, Washington, D. C. (Elected to the GQRA, No. 183).

I would like to submit an answer to Freakish Question, No. 794 in the April issue of SCHOOL SCIENCE AND MATHEMATICS.

The bottle of pop which remained in the liquid phase while a similar one at the same temperature was frozen solid represented a case of supercooling. For some reason not well understood the contents of the one bottle being undisturbed had reached a temperature below its freezing point without assuming the solid phase. Of course the other bottle was undisturbed also but the result was not the same. The molecules of the liquid had failed to arrange themselves in the pattern characteristic of the solid. By the act of attempting to drink the contents of the bottle the molecules of the liquid were agitated and given just the required energy to effect the change to the solid phase. A parallel may be seen in the case of the supersaturated solution. It is possible to bring about crystallization down to the saturation point merely by scratching the walls of the beaker with a

glass rod. Apparently just enough energy is imparted to the liquid molecules to bring about the change of state.

To my mind this fairly well explains the phenomena referred to in the question. If it meets with your approval I would like to have you print it in SCHOOL SCIENCE AND MATHEMATICS.

Other solutions were received from
Roy C. Hatch, Silliman Laboratory,
Mount Hermon School, Mt. Hermon, Mass.
(Elected to the GQRA, No. 184).
John M. Michener, Wichita High School East, Wichita, Kansas
(GQRA, No. 117)
Jerome C. Forma, Augsburg College (GQRA, No. 102).

QUESTIONS THAT CAUSED US TROUBLE

789. *Submitted by Theodore J. Kuemmerlein (GQRA, No. 160), Boys Technical High School, Milwaukee, Wisconsin.*

Several questions relating to the simple pendulum were given.

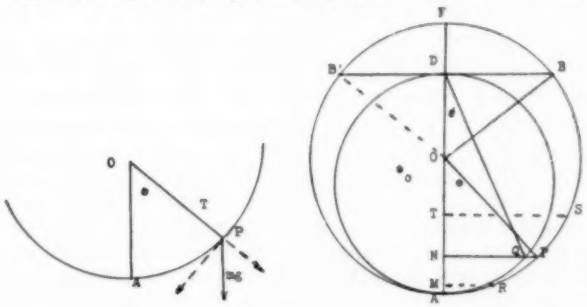
Discussion by Clyde A. Bridger, Chemistry Instructor, Mackay High School, Mackay, Idaho (GQRA, No. 157)

Since so many questions center around the simple pendulum, I have set forth at length a summary of some information I found stored up in class notes when I was taking science courses in college. They answer all except the first question: "Just what is a Seconds Pendulum?" A seconds pendulum is really any simple pendulum in which the period is one second, of course, but that is insufficient answer to the question. The other questions are included without distinction in the following article:

THE SIMPLE PENDULUM

The ideal simple pendulum is a particle P of mass m suspended by a weightless thread $OP = 1$ from a support 0. (Fig. I.) The path described is an arc of a circle of radius OP. Consider the forces acting on P. The weight of P due to the acceleration of gravity is mg and directed downwards. The tension of the string is T and is directed along the string. The acceleration of P along arc AP has the components: tangential: $m(dv/dt) = -mg \sin\theta$ and normal: $(mv^2/1) = T - mg\cos\theta$, since the acceleration is always directed towards the center of curvature. P has the *linear* velocity of v along the arc. The work done in moving a unit distance PP' along the arc is

(1) $\quad d(\frac{1}{2}mv^2) = mg \sin\theta(-ds) = -mgl \sin\theta\, d\theta$, since $ds = 1d\theta$.



Let B, Fig. II, be the highest point of the swing. Then we have $\theta=\theta_0$, $v=0$, and $t=0$ at the beginning. The first integration of (1) yields $\frac{1}{2}v^2=gl\cos\theta+C$ where $C=-gl\cos\theta_0$ from the initial conditions. Now, $v=ld\theta/dt$, where $d\theta/dt$ is the *angular* velocity of P. The integral is (2) $L^2(d\theta/dt)^2=2gl(\cos\theta-\cos\theta_0)$. Let us next write $g=ln^2$, where n is a constant. From the trigonometric functions of half an angle, we have $\cos\theta=1-2\sin^2\frac{1}{2}\theta$. From (2) we now have (3): $(d\theta/dt)^2=4n^2(\sin^2\frac{1}{2}\theta_0-\sin^2\frac{1}{2}\theta)$. Also, let us set $\sin\frac{1}{2}\theta/\sin\frac{1}{2}\theta_0=\sin\phi$, or $MR/TS=NQ/DQ$ in Fig. II. Then differentiation with respect to t yields (4) $d\theta/dt=\dfrac{2\sin\frac{1}{2}\theta_0\cos\phi\,d\phi/dt}{\sqrt{1-\sin^2\frac{1}{2}\theta_0\sin^2\phi}}$. Further (3) becomes (5): $(d\theta/dt)^2=4n^2\sin^2\frac{1}{2}\theta_0(1-\sin^2\phi)$ after substitution. By setting the value of $d\theta/dt$ in (4) into (5) and reducing, we have (6): $n\,dt=d\phi/\sqrt{1-\sin^2\frac{1}{2}\theta_0\sin^2\phi}$. This is, of course, of the form of the integrand of Legendre's Elliptic Integral of the First Kind. If we put $\sin^2\frac{1}{2}\theta_0=k^2$, where k is the modulus and equals TS/OP in Fig. II, we can integrate (6) to the form (7): $nt=F(\phi,k)=\text{arc }sn(\sin\phi,k)$.

To find the coordinates of P with the origin of the axes at 0, we have $x=l\sin\theta$ and $y=l\cos\theta$. At any time, t, of the motion, these are found thus: From the integral we have $\sin\phi=sn(t,n)$, modulus k. Whence, $\sin\frac{1}{2}\theta=\frac{1}{2}\theta_0\,sn(t,n)$ and $\cos\frac{1}{2}\theta=dn(t,n)$. From these half angle values x and y may be obtained.

To obtain the period of the motion, we have from (7): $nt=F(\phi,k)=\int_0^{\phi}\dfrac{d\phi}{\sqrt{1-k^2\sin^2\phi}}$ to give us the time t for any ϕ. The time for the quarter period is found by examining Fig. II to get the limits of ϕ. We note that DQ coincides with DB when $\theta=\theta_0$ and coincides with DA at $\theta=0$. This range of θ is just one-fourth of the full range of θ from B through A to B' and then back to B. The corresponding range of ϕ is angle BDA and $=\pi/2$ radians. Then the *quarter period* of the motion is $(nt)_{\frac{1}{4}}=\int_0^{\pi/2}\dfrac{d\phi}{\sqrt{1-k^2\sin^2\phi}}=K$ (modulus k). K is the real quarter-period of the elliptic integral and corresponds to $\pi/2$ for trigonometric functions. (In fact, the inverses of the elliptic integrals, called elliptic functions, are doubly periodic with a real and an imaginary period. Similarly, trigonometric functions are simply periodic with a real period and hyperbolic functions are simply periodic with an imaginary period.) Recalling the value of n above, we find that the *PERIOD OF THE MOTION IS* $4K\sqrt{l/g}$, (modulus k).

In high school work, k is set equal to unity, that is $TS=OP$ in Fig. II. In this case, the *period* is $4(\pi/2)\sqrt{l/g}=2\pi\sqrt{l/g}$. This is a first approximation to the true period given above. Comparison of periods for a couple of cases might be of interest. If the initial angle is 20° (from the vertical OA), the actual period is $4K\sqrt{l/g}=6.3312\sqrt{l/g}$. The approximate period is $2\pi\sqrt{l/g}=6.2832\sqrt{l/g}$. If $\theta_0=30°$, we have the actual period as $6.3924\sqrt{l/g}$ and the approximate period the same as before. (Values of K for different moduli k and of the elliptic functions $sn\,u$, $cn\,u$, and $dn\,u$ may be obtained from Milne-Thompson's "Tables of Elliptic Functions.")

Differences between the high school approximation and the complete result are brought about through the fact that the time of swing of the pendulum is dependent upon the amplitude, θ, of the swing. All the principal steps used in the preceding discussion can be pictured as in Figure II.

In figure II, B is the highest or initial point of P, A is the lowest point. BD, ST, PN and MR are all perpendicular to AF. S is midpoint of arc AB; R is midpoint of arc AP. θ is amplitude corresponding to the angle θ. $\sin \frac{1}{2}\theta_0 = TS/OP$; $\sin \frac{1}{2}\theta = MR/OP$.

BOOKS AND PAMPHLETS RECEIVED

The Living World, by Samuel H. Williams, Professor of Zoology in the University of Pittsburgh and Associate Director of the University Lake Laboratory. Cloth. Pages xxii+704. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.60.

Calculus, by Joseph Vance McKelvey, Professor of Mathematics, Iowa State College, Ames, Iowa. Cloth. Pages ix+420. 13×19.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

More for Your Money, A Buyer's Guide, by H. Bennett. Cloth. Pages xii+251. 15×22.5 cm. 1937. Chemical Publishing Company, Inc., 148 Lafayette Street, New York, N. Y. Price $2.75.

Mathematics Through Experience, Book Three, by Joel S. Georges, Chairman of Department of Mathematics, Wright Junior College, Chicago; Robert F. Anderson, Formerly Professor and Head of Department of Mathematics, State Teachers College, West Chester, Pennsylvania; and Robert L. Morton, Professor of Mathematics, College of Education, Ohio University. Cloth. Pages ix+486. 13×20 cm. 1937. Silver Burdett Company, 39 Division Street, Newark, N. J. Price $1.28.

General Mathematics for Students of Business, by William S. Schlauch, New York University. Cloth. Pages ix+394. 15×23 cm. 1936. F. S. Crofts and Company, 41 Union Square, West, New York, N. Y. Price $3.75.

Elements of Foods and Nutrition, by Mary T. Dowd, Formerly Teacher of Household Science, Washington Irving High School, New York City, and Alberta Dent, Associate Professor of Home Economics, New Jersey College for Women. Cloth. Pages xiii+279. 13×19.5 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.75.

The Little Things in Life, by Barnett Sure, Professor of Agricultural Chemistry in the University of Arkansas. Cloth. Pages xi+340. 13.5×21.5 cm. 1937. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price $2.50.

Methods of Biology, by Alfred C. Kinsey, Professor of Zoology , Indiana University, Bloomington, Indiana. Cloth. Pages x+279. 13.5×20.5 cm. 1937. J. B. Lippincott Company, 220 North Michigan Avenue, Chicago, Ill. Price $2.50.

Senior Science, by George L. Bush, Assistant Principal, South High School, Formerly Head of the Science Department, John Adams School, Cleveland, Ohio; Theodore W. Ptacek, Instructor of Science, John Adams High School, Cleveland, Ohio; and John Kovats, Jr., Instructor of Science, John Adams High School, Cleveland, Ohio. Cloth. Pages vii+835, 15×23 cm. 1937. American Book Company, 360 North Michigan Avenue, Chicago, Ill. Price $2.20.

Organic Chemistry Laboratory Guide, by E. Wertheim, Professor of Organic Chemistry in the University of Arkansas. Paper. Pages xii+524. 21×28 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.00.

Educational Opportunities in Missouri High Schools, by Byron Less Westfall, Central Missouri State Teachers College, Warrenburg, Mo. Paper. Pages x+190. 14.5×23 cm. 1937.

Directed Studies in General Science, by Donald H. Painter, Teacher of General Science, Roosevelt High School, Dayton, Ohio, and George J. Skewes, Head of Department of Education, State Teachers College, Mayville, North Dakota. Paper. Pages xiii+242. 19×25.5 cm. 1937. Mentzer, Bush and Company, 2210 South Park Way, Chicago, Ill. Price 60 cents.

The Wonderful Wonders of One—Two—Three, by David Eugene Smith. Cloth. 47 pages. 15.5×22 cm. 1937. McFarlane, Warde, McFarlane, Inc., 6 East 45th Street, New York, N. Y.

Useful Mathematics, by Flora M. Dunn, Head of the Mathematics Department, Fairfax High School, Los Angeles, California; Emmy Huebner Allen, Teacher of Mathematics, Fairfax High School, Los Angeles, California; John S. Goldthwaite, Chairman of the Mathematics Department, Lincoln High School, Los Angeles, California; and Mary A. Potter, Supervisor of Mathematics, Racine, Wisconsin. Cloth. Pages x+422. 13×20 cm 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.32.

Algebra for Today, First Year, by William Betz, Vice-Principal of the East High School and Specialist in Mathematics for the Public Schools of Rochester, New York, Cloth. Pages xii+565. 14×21 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.36.

Plane Trigonometry, by Arthur M. Harding, Professor of Mathematics, University of Arkansas, and George W. Mullins, Professor of Mathematics, Barnard College, Columbia University. Revised Edition. Cloth. Pages vii+172. 13×19.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.60.

Modern Everyday Chemistry, by Ralph E. Horton, Chairman of the Department of Science, Seward Park High School, New York City. Cloth. Pages viii+451. 13×21 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.68.

General Mathematics, by Harris Crandall, Superintendent of Schools, Saratoge Springs, New York, and F. Eugene Seymour, Supervisor of Mathematics, New York State Department of Education, Albany, New York. Cloth. Pages v+389. 13×21 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.28.

College Algebra, by Claude Irwin Palmer, Late Professor of Mathematics and Dean of Students, Armour Institute of Technology, Author of a Series of Mathematics Texts; and Wilson Lee Miser, Professor of Mathematics, Vanderbilt University. Second Edition. Cloth. Pages xvi+467. 12×18.5 cm. 1937. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.50.

Explorations in Biological Science, by James C. Adell, Chief, Bureau of Educational Research, Cleveland Public Schools: Orra Olive Dunham, Biology Department, Collinwood High School, Cleveland, Ohio; and Louis E. Welton, Formerly Head of the Science Department, Assistant Principal, John Hay High School, Cleveland, Ohio. Paper. Pages vi+345. 19×27.5 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.12.

Thompson Business Practice Test, by James M. Thompson, Instructor in Management, School of Commerce, New York University. Form A.

Paper. 14 pages. 16×25.5 cm. 1937. World Book Company, Yonkers-on-Hudson, New York, N. Y. Sold in packages of 25, with complete directions, at $1.15 net per package.

Teachers Manual to Accompany Descriptive Physics, by Sherman R. Wilson, Head of the Exact Science Department, Northwestern High School, Detroit, Michigan. Paper. 27 pages. 13×19 cm. 1937. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y.

Numbers and Numerals, by David Eugene Smith and Jekuthiel Ginsburg. Paper. Pages viii+52. 13.5×20 cm. 1937. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price 25 cents.

Kefauver-Hand Guidance Tests and Inventories, by Grayson N. Kefauver and Harold C. Hand, with Miss Virginia Lee Block and Dr. William M. Proctor. Six tests and two inventories. World Book Company, Yonkers-on-Hudson, New York, N. Y.

Konstruktionen der Drei Klassischen; Quadratur, Duplicatio Cubi, Trisektion, von Artillerie—Oberst A. D. Emanuel Quoika. Paper. 16 pages, six figures. 15×22.5 cm. 1936. Wien, IV. Schleifmühlgasse 21.

Arithmetic of the Alternating, by Robert Ashby Philip. Paper. Pages iv+125. 21×27.5 cm. 1937. The Monographic Press, 106 Washington Street, Fairhaven, Mass. Price $3.00.

BOOK REVIEWS

Mathematics Through Experience, Book One, Book Two, and Book Three, by Joel S. Georges, Chairman of Department of Mathematics, Wright Junior College, Chicago; Robert F. Anderson, Formerly Professor and Head of Department of Mathematics, State Teachers College, West Chester, Pennsylvania; and Robert L. Morton, Professor of Mathematics, College of Education, Ohio University. Cloth. Book One, vi+394+27 pages. 13.5×19.5 cm. 1937. Price $1.00. Book Two, vi+394+27 pages. 13.5×19.5 cm. 1937. Price $1.04. Book Three. ix+486. 13.5×19.5 cm. 1937. Price $0.96. Silver Burdett Company, 39 Division Street, Newark, N. J.

At the present time curriculum makers and school administrators are questioning the advisability of requiring mathematics of all high school pupils. In some cities and states mathematics has been placed on the optional list. This situation has been brought about apparently because many administrators believe that mathematics has little cultural and practical value for a majority of the pupils and because they further believe that a large number of pupils do not have the mentality to comprehend mathematics. The blame for this belief may, to a very large extent, be charged to teachers of mathematics who have taught the subject as an exercise in symbol juggling.

Mathematics should be taught as a method of thinking. Mathematical thinking to a very large extent is concerned with quantities and the relationships between quantities. The child is surrounded with quantitative material. When mathematics is taught as a method of thinking applied to the quantitative material within the range of the child's experience and comprehension, it becomes an interesting and dynamic subject. The authors of the books under review are alive to the possibilities in the selection of this quantitative material and also to the methods of its presentation.

Book One is divided into three parts with titles as follows:

Part I. Getting Acquainted with Geometry
Part II. Learning more about the Uses of Arithmetic
Part III. Learning more about Geometry

Each of the parts is divided into units of instruction. In Part I we find four units as follows: Representing Quantities by Lines; Learning to Use Angles; Studying Related Quantities; Graphs; and Discovering Facts about Geometric Figures. In Part II we find four units as follows: Use of Decimal Fractions, Use of Per Cents, Solution of Problems, and the Use of Decimals and Per Cents at Home and in Business. In Part III there are units on the Constructions of Geometry, Congruent Geometric Figures, Similar Geometric Figures, and Symmetry of Geometric Figures.

Book Two is likewise divided into three parts as follows:

Part I. Renewing Acquaintance with Albegra
Part II. Learning how Algebra and Geometry Cooperate
Part III. Seeing how Algebra and Arithmetic Cooperate

Part I deals with the use of simple equations, use of formulas, and the use of algebra in solving formulas. Part II is concerned with finding areas of geometric figures, the use of the right triangle, measurement of solids, and more about the use of graphs. In Part III we find units on: How Credits are Maintained, Banking; How Money Is Put to Work, Investments; How Risk is Combined, Insurance; and How Governments are Financed, Taxation.

Book Three is divided into four parts with the following headings: Studying Relationships, Learning Algebraic Processes, Solution of Equations, and Studying Geometric Methods. In Part I there are units on The Formulas, The Graph, The Equation, and Problems. In Part II we find units on Operations with Directed Numbers, Fundamental Operations, Special Products and Their Factors, Fractions, and Radicals and Exponents. The units of Part III deal with equation of first degree in one letter, linear simultaneous equations in two letters, fractional equations, quadratic equations, and variation. In Part IV we find a unit on Numerical Trigonometry and one on Geometric Proof.

In all of these books emphasis is placed on the fact that mathematics is a method of thinking which is to be acquired and used by the child. To these ends mathematical material is so presented that he is observing, experimenting, testing his understanding, drawing conclusions and applying them to new situations. In each unit we find an introductory story which enumerates the objectives of the unit so that both teacher and pupil are aware of what is to be accomplished. There are developmental exercises which introduce the concepts and processes to be used and exercises which are designed to give practise in their use. These exercises are divided into three groups—A, B, and C. The A-group is for the class of average ability, the B-group for a more mature class, or one with more time at its disposal, the C-group for pupils of superior ability. At the end of the unit we find an outline on the basis of which the pupil may write a review of the unit. For the evaluation of the instruction recall drills and tests are included.

Every teacher of junior high school mathematics should carefully examine these books.

J. M. KINNEY

Introduction to the Mathematics of Business, by William L. Hart, Ph.D., Professor of Mathematics, University of Minnesota. Cloth. Pages 321 +79. 13.5×20 cm. 1936. D. C. Heath and Company. Price $2.60.

This book has developed out of the attempt to give students in the General College of the University of Minnesota a type of mathematics which would appeal to those who expect to terminate their college work at the end of two years. The aim in planning the book has been not only to give the student a large amount of useful mathematics but also an appreciation of the extended use of mathematics in modern civilization.

The first three chapters are devoted to the processes of elementary algebra. In Chapter 4 we find a discussion of significant figures and the treatment of operations involving approximate numbers. The remaining fourteen chapters for the most part deal with topics relating to business. The chapter headings are as follows: Simple Interest and Simple Discount; Functions and Graphs; Systems of Linear Equations; Logarithms; Topics related to Statistics; Compound Interest; Progressions; Annuities with Simple Data; Extinction of Debts by Periodic Installments; Bonds; Depreciation, Perpetuities, and Capitalization; General Annuity Formulas; Life Annuities; and Policy Reserves.

J. M. KINNEY

Calculus, by Joseph Vance McKelvey, Professor of Mathematics, Iowa State College, Ames, Iowa. Cloth. Pages ix+420. 13.5×20 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

In the presentation of the material of this book the author has tried to steer a middle course between the extreme of a precise analytical formulation and that of an intuitive procedure. The book comprises the usual material found in a first course of the calculus. The first half of the text is devoted to the differential calculus and the second half to the integral calculus. There are numerous figures which are better done than the common run. The typography is superior.

J. M. KINNEY

Culture Methods for Invertebrate Animals, A Compendium prepared cooperatively by American zoologists under the direction of a committee from Section F of the American Association for the Advancement of Science, by Paul S. Galstoff, Frank E. Lutz, Paul S. Welch, James G. Needham, Chairman, assisted by many specialists whose names appear in connection with their respective contributions to this volume. Cloth. Pages xxxii+590. 15×23 cm. 1937. Comstock Publishing Company, 124 Roberts Place, Ithaca, N. Y. Price $4.00.

This book is a compilation of short articles, most of which have been specially prepared by one hundred and eighty-six contributors who responded to the call (published in *Science*, 1933) for such materials. The first few sections, written by members of the committee, deal with general principles and methods for the collecting and culturing of invertebrate animals. The remainder of the book consists of articles by contributors—supplemented by abstracts and reprints from the literature—giving detailed descriptions of methods for particular animals.

The groups are taken up in phylogenetic order, beginning with the Protozoa and ending with the Ascidacea. Seventeen phyla are considered. The relative importance of the Arthropoda is reflected by the fact that three-fifths of the space is devoted to this group, with the insects capturing the lion's share.

The book fills a void in the literature of zoology, although as the editors modestly admit. "This is only a beginning. The gaps in our knowledge are

numerous and very obvious. Comparatively few invertebrate animals have been tried as yet, and very few have been managed with complete success." Nevertheless, the book contains a surprising amount of valuable information not readily available elsewhere. Its publication will no doubt stimulate the development and publication of new methods.

This quotation from the preface will be of interest to the high school teacher: "Some very simple procedures are included. We have not forgotten the needs of the high school teacher who is wise enough and diligent enough to teach zoology with the saving grace and with the quickening thrill that comes from the use of living materials."

The material of the book is conveniently arranged. Numerous drawings illustrate the apparatus described. Bibliographies are appended to many of the articles. A suggestion regarding the index—which in general is quite complete—may be in order. Many of the words indexed are followed by several page numbers, and in no case is there a clue as to which page the reader may wish to consult. As an extreme example, the word "collecting" is followed by twenty-three page numbers, with no hint as to what is considered on any of the pages referred to. In future editions the printing of subheadings in the index would seem well worth the extra space and labor involved.

The publishers are to be commended for the excellent type, good quality of paper, and substantial binding.

EDWARD C. COLIN

College Biology, by Walter H. Wellhouse, Professor of Biology and George O. Hendrickson, Assistant Professor of Zoology, Iowa State College. Cloth. Pages viii+381. 14×21.5 cm. 1936. F. S. Crofts & Co., New York. Price $3.00.

This is one of the smaller of the recent texts in college biology. It has been prepared to take the place of the authors' "A Brief Course in Biology" and is the product of thirteen years teaching general biology to college freshmen. Like nearly all of its contemporaries the book is meant to be accompanied by laboratory exercises, which is probably the reason for detailed descriptions of earthworm and frog anatomy.

The sequence of topics is the usual one in similar books: Protoplasm and the Cell; One-celled Organisms; Plant Groups; Animal Groups; Vertebrate Structure and Physiology; "Development of Modern Animals" (really a discussion of Fossils and Comparative Morphology); Behavior and Heredity; The Struggle for Existence and Adaptations; with a final chapter on Cooperation. Throughout the last few chapters the evolutionary implications of the discussion are evident; nevertheless, the word "evolution" was noted only once, and that on the last page of the book in a discussion of social customs of man. It does not appear in any of the chapter or section headings and is not to be found in the index. One wonders whether there is some special reason for shunning the word which to many biologists has become the most significant one in all biology.

The textual matter is interestingly written, with the general student primarily in mind. It is illustrated by an adequate number of drawings, in most cases well chosen for the purpose. Few errors have been encountered. In the section on Heredity (p. 334) the statement is made that Mendel "believed his principle of dominance had universal application," whereas Mendel states in his famous paper that in one character (flowering time) the hybrids were intermediate. On page 336 the now discredited presence and absence theory of genes is restated. On page 311, what appears to the reviewer as an unfortunate analogy is drawn when cell division in Protozoa

is compared to the "dissolving of a crystal in its mother liquor and the subsequent formation of similar crystals from it anew."

In spite of the above and some other less important criticisms of phraseology the book can be recommended as a well balanced and skillful presentation of the fundamental principles of biology.

EDWARD C. COLIN

New Elementary Physics by Robert Andrews Millikan, director of the Norman Bridge Laboratory of Physics, California Institute of Technology, and Henry Gordon Gale, Professor of Physics in the University of Chicago; being a revision of the authors' *Elements of Physics* done in collaboration with James P. Coyle, Head of the Department of Physics, Lane Technical High School, Chicago. Cloth. Pages xiv+637. Size 14.5×20.3 cm. 1936. Ginn and Company, New York. Price $1.80.

In its physical aspect the text is a fine, attractive example of modern press work. Both the line drawings and the half tones are exceptionally well done.

The text has an "indispensable backbone" and specially designated amplifying sections that may be assigned at the option of the instructor. Care has been taken to keep the vocabulary sufficiently simple. The material is organized in seven units with an introduction to each unit. Each unit is made up of several chapters and the chapters are broken up with questions and problems in two grades of difficulty.

In addition to the 555 figures that form an organic part of the text, there are 128 page illustrations with rather full explanations. These were not selected and interspersed with the intention of making them strictly an accompaniment to the main course but rather with the idea that they should form practically a separate course to stimulate and inspire the student in the study of the history of physics, the accomplishments of its "heroes," and its applications in commerce and industry. Included here are very recent pictures such as those of the South Dakota stratosphere flight, air conditioning, and wire transmission of photos.

This text merits general recommendation and is especially commendable in one respect: when an explanation is undertaken it is completed in a thorough fashion.

A. H. GOULD

Mechanics, Molecular Physics, Heat and Sound, by Robert Andrews Millikan, Director of the Norman Bridge Laboratory of Physics, California Institute of Technology; Duane Roller, Professor of Physics, University of Oklahoma; and Earnest Charles Watson, Professor of Physics, California Institute of Technology. Cloth. Pages xiv+489. 15×23 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $4.00.

This is a textbook for use in the first half of the course in general physics. It is practically a new book but based on Millikan's *Mechanics, Molecular Physics and Heat*. It aims at thoroughness rather than extensiveness. It does not aim to make physics attractive to students who have no serious interest in the subject, but presents a thorough course on fundamental principles for students who have profited by a good high course and have a desire to go farther in science. The general plan is to give a rather comprehensive treatment of a limited number of fundamental principles. Each topic is first presented in descriptive and qualitative form; some of the historical setting is given, largely by use of pictures and quotations from

original papers so inserted that the continuity of explanation is not interrupted; the analytical treatment is then presented, followed by one or more illustrative experiments and lists of well selected problems. Trigonometry and elementary calculus are made use of throughout.

A very important part of the book is the rather extensive annotated bibliography for aiding both teacher and student, and the appendix with instructions for use of the common measuring instruments, explanation of symbols used, and useful tables. The book is attractive in appearance, thorough and reliable in subject matter, and combines text and laboratory manual in one volume. It will no doubt be a favored textbook for engineering and science students but will be passed up by those wanting only a descriptive course.

G. W. W.

The Renaissance of Physics, by Karl K. Darrow, Research Physicist, Bell Telephone Laboratories. Cloth. 306 pages. 14.5×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

After many years spent in study and research in the realm of modern physics with occasional lectures and publications Dr. Darrow has now acquired an enviable record as a lecturer and writer. This book is the result of an attempt to explain in a non-technical style the present concepts of the structure of matter and its relation to energy, and to show briefly how these conclusions have been reached. It is a difficult undertaking to those without a background of scientific study many of the modern theories of matter and energy, and to give satisfactory word pictures of the processes taking place in atomic systems. The measurement of atomic dimensions, the value of unit charges, the nature of radiation, the processes of transmutation, the character of magnetism—all these fundamentals of modern science are portrayed as vividly as written composition permits. The book was written especially for lay readers but its pleasing style and wealth of solid physics make it equally interesting and valuable to students and teachers of physics.

G. W. W.

Webster's Collegiate Dictionary. Fifth Edition. Pages xxvi+1274. 4.5×16.23 cm. 1800 illustrations. Thin paper. Indexed. Buckram. 1936. G. & C. Merriam Company, Springfield, Mass. Price $3.50.

This new edition is based on Webster's New International Dictionary and contains many features desirable for individual or school use. There are 110,000 entries, each word introduced in bold type, yet the thin paper makes possible a compact book. Definitions are brief, clear, and instructive. Take the word *lever* as an example. Its pronunciation and derivation are clearly indicated; the term as used in mechanics is fully defined; the idea is then made objective by illustrations of the three classes of levers. Many words having a wide range of meaning are not only fully defined but have their meanings clarified by a list of synonyms. The Appendix offers a wealth of useful information on such topics as abbreviations, foreign words and phrases, punctuation, pronunciation of geographical names, and the like. In school, home, or busines office this new dictionary will become the servant and friend of many a busy worker.

W. F. ROECKER

Directed Study Guide and Manual (to accompany Davis and Sharpe's *Science*), by Ira C. Davis, Head of Department of Science, University High School, Assistant in the Teaching of Science, School of Education,

University of Wisconsin. Paper. Pages viii+194. 21×28 cm. 1936. Henry Holt and Company, 257 Fourth Ave., New York, N. Y. Price, 60 cents.

This book of ninety-six exercises is an excellent manual and guide for science students and teachers alike. It contains many features which justify the use of a manual in an elementary course in science. Only a limited number of experiments are presented; just enough to provide a physical basis for the numerous study exercises. The main stress is laid on scientific reasoning and the organization of important units of science; thus high lights are thrown on important facts, principles, and applications. There are a number of sets of review and test questions; a variety of charts and drill materials are supplied; some exercises are specifically designed to develop scientific attitudes; others show how science has contributed to human progress.

The book is stitched so it will open flat; the sheets are perforated so they can be detached and handed in; they are also punched so they will fit the rings of any loose-leaf cover. Blanks are provided for short answeres.

In general the exercises are clear, thorough, and the field is covered quite comprehensive. It is remarkable how much worth-while science can be impressed on the student by means of a guide of this kind. For best results it should be used with the text *Science* by Davis and Sharpe, which was reviewed in the February issue of SCHOOL SCIENCE AND MATHEMATICS.

W. F. ROECKER

The Teaching of Mathematics in the New Education, by N. Kuppuswami Aiyaugar, Mathematics Lecturer, Training College, Trivandrum, South India. Pages 420. G. E. Strechert and Company; New York.

The real teachers of mathematics, and those who still believe that the subject is worthy a place in the curriculum of this socalled modern world will give an eager welcome of this book from foreign shores. If one has not been aware that forces in other countries would drive mathematics out of school life, a reading of this interesting and well written book will change his point of view.

This contribution with a background of some 30 years of teaching in India is not so much a book as it is a library on the subject of Teaching Mathematics. It includes a philosophy of education which finds a place for mathematics. It has a great wealth of quotations preceding each chapter from educators and thinkers of both past and present. The book reveals a man well abreast of the reform thinking and planning which many believe will be the chief agencies in saving mathematics for a vast group of children who would like to study it. In the more than four hundred pages one reads a clearly written discussion on the Scope and Use of Mathematics, Mathematical Ability, The Theory of Formal Discipline, Should Everybody Study Mathematics, The Curriculum in Mathematics, Methods of Teaching Mathematics, with reference to Arithmetic, Algebra and Geometry.

The book does not press new fads about mathematics but rather does it offer a common sense approach to the problems facing the subject As such it merits a large place in the increasing amount of literature which seeks to keep mathematics in the curriculum.

G. H. JAMISON

A First Course in the Differential and Integral Calculus, by Walter Burton Ford, Professor of Mathematics, The University of Michigan. Revised Edition. Cloth. Pages vii+369. 15×23.5 cm. 1937. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $3.00.

This is a revised edition of the text published in 1928 by the same author. The usual topics found in text books on calculus are discussed in the customary order. One of the features of the book is the abundance of examples and exercises. A number of additions have been made to the some two thousand examples originally given in the text, over one-half of which are accompanied by answers, approximately one-third are without answers, and the remainder are completely solved and serve as illustrations. In revision the author has endeavored to start each page with a section heading or exercise list. Important facts, formulas and theorems are set out in bold type. A strictly rigorous proof of these theorems cannot be given in all cases but will be found satisfactory for the student of elementary calculus. Wherever possible the author has given emphasis to the applications of calculus to elementary physics. The completeness of the tables included will be recognized as a commendable feature. Not only have the standard integrals been included but also trigonometric formulas, four-place sine, cosine and tangent tables expressed in radians at 10′ intervals from 0 to 90, and a table of squares, square roots, cubes, cube roots and reciprocals of all integers from 1 to 100. Although this edition is not as long as the first the material has been broken up into twenty-four chapters instead of seventeen. This should provide for greater convenience and flexibility for the teacher as well as the unification of material for the benefit of the student.

L. C. WARNER

Analytic Geometry and Calculus, by Bolling H. Crenshaw, Late Head of Department of Mathematics, Alabama Polytechnic Institute, and Cincinnatus D. Killebrew, Late Professor of Mathematics, Alabama Polytechnic Institute. Second Edition revised by Ralph D. Doner, Professor of Mathematics, Alabama Polytechnic Institute. Cloth. Pages xii+222. 15×23 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.75.

This text, originally written by Professor Crenshaw and Killebrew of Alabama Polytechnic Institute, has now been revised by Professor Doner of the same institution. The book was written for the purpose of satisfying in the allotted two years the mathematical demands of the engineering student. A number of theoretical and non-essential concepts have been eliminated so that the student may obtain a working knowledge of the student may obtain a working knowledge of the mathematics needed in engineering in a minimum amount of time. The book is divided into eighteen chapters, the first of which is a review of algebra and trigonometry; the next seven chapters consider the aspects of analytic geometry, and the remaining ten are devoted to calculus. Only the easy proofs are given; the more difficult and less rigorous ones have been omitted. Answers for all odd numbered exercises, ample tables of data, formulas and reference curves make up the last section of the book. Teachers of mathematics for engineering students should be interested in looking over this text.

L. C. WARNER

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OBLONG ROOTS?

This is an algebraic square:

$(u-3)^2 = (u-3)\,(u-3) = u^2 - 6u + 9$

This is an algebraic square root:

$\sqrt{u^2 - 6u + 9} = {}^2\sqrt{[+(u-3)]^2}$ or ${}^2\sqrt{[-(u-3)]^2} = +(u-3)$ or $-(u-3)$

This is an algebraic oblong:

$(u-3)\,(u-2) = u^2 - 5u + 6$

This is an hypothetical algebraic oblong root:

${}^?\sqrt{u^2 - 5u + 6} = {}^?\sqrt{(u-3)\,(u-2)} = (u-3)$ or $(u-2)$

That hypothetical formula merely illustrates the analogy of the idea "oblong root" to the idea "square root"; the formula does not define a determinate algebraic operation.

Squares and square roots are equivalent to algebraic rotations in the plane of complex numbers.

The plane of complex numbers floats in the space of bifoliate numbers.

Oblong powers and oblong roots, which are indeterminate operations in complex numbers, become determinate operations in bifoliate numbers and are equivalent to polyarithmic (nonalgebraic) rotations in the space of bifoliate numbers.

This is a polyarithmic oblong power;

$(u-3\&2)^? = (u-3\&2)\,(u-2\&3) = u^2 - 5u + 6$

This is a polyarithmic oblong root:

${}^?\sqrt{u^2 - 5u + 6} = {}^?\sqrt{(u-3\&2)^?}$ or ${}^?\sqrt{(u-2\&3)^?} = (u-3\&2)$ or $(u-2\&3)$

This simple application of polyarithmic roots to the formal solution of quadratic algebraic equations may be extended to equations of higher degrees which are incapable of solution by means of the usual algebraic roots. This thesis is developed by Robert A. Philip in three monographs:

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SOME NOTES ON PFEFFERKORN'S ARTICLE IN THE APRIL ISSUE

By CHARLES H. STONE

If a rubber stopper does not slip off the glass tube by the method suggested in the article, it can frequently be loosened by working a little water between the rubber and the glass all the way around on both ends of the stopper.

Rubber stoppers which have become hard may be softened by soaking them in a solution of sodium hydroxide.

When pouring a liquid reagent from a bottle, remove the drop which clings to the lip of the bottle by turning the bottle part way around with lip resting against the receiving vessel. This prevents the drop from running down on the outside of the bottle so that you get the liquid on your fingers the next time you pick up that bottle.

When weighing dry chemicals, put *two* papers of equal size and weight on the two pans of the platform scales. No adjustment will then be necessary for the weight of the single paper.

When pouring dry chemicals from a bottle, roll the bottle back and forth so that the chemical comes out in small amounts at a time; if you continue to tip the bottle up without rolling, by and by, a big lot of the chemical comes out all at once, spilling all over the place.

When measuring liquids in a graduate, hold the graduate by the top so that it hangs vertically. If held at or near the bottom, a slight inclination from you or towards you will result in an incorrect reading.

SHALL WE DISCARD GEOMETRY?

BY CLYDE A. BRIDGER
Mackay High School, Mackay, Idaho

Geometry is a word derived from two Greek words meaning "to measure the earth." It originally meant just that. The establishment of relationships amongst several discoveries made in measuring the earth divided geometry into two fields: the actual measurement of the earth and a study of the discovered relationships. The loose ends of this latter field were gathered together by a Greek named Euclid about 300 B.C. The Geometry now being studied is based upon this man's work and related discoveries since.

In Plane Geometry, we assume we have points and lines lying in one plane. (The lines may be curved.) The whole study revolves around the combining of these points and lines into groups called geometric figures. Relationships amongst these figures are shown to exist through the use of axioms, postulates and other already proven relationships. If we wish to test a relationship we think might exist, we set up a theorem. This is merely a statement of condition requiring proof. The actual proof is effected through axioms, postulates and other proven theorems.

Geometry has two uses. One major use is to give us proof of the correctness of different designs in dress-making, bridge construction, and the like. The other is to provide us with a method of organizing our thinking so that we may set up the problems of our everyday life for solution and reach the correct conclusion for the assumptions we have made. It is this latter use that lies behind the request for enrollment in a high school Geometry course. This goal is usually lost simply because we are so busy trying to work sample problems presented by the author of the particular text assigned for use that we have neither the time nor the patient to make any transfer of idea or application to daily usage. For that reason, does not high school Geometry fail us in this our present day?

A sad commentary on the subject of Geometry is the fact that the material presented in the usual course is generally not used in the ordinary advanced study of mathematics. Even fields of advanced geometry are ordinarily examined through the medium of an analytic geometry and

not on the material given in a Euclidean course. It is true that certain theorems are assumed to have been proven valid. Except for these, the geometric methods of analysis mentioned above as the lost goal is all that is salvaged for future use even by the pure mathematician. Cannot geometry, therefore, be merged with algebra to present the necessary geometric data and to reach the end desired of the present Geometry course? The axioms of algebra and geometry are the same; many of the postulates of geometry are already assumed in algebra, so also are many of the theorems, such as the Pythagorean Theorem. Can we not, then, remove this piece of dead timber from our high school curriculum and substitute an analytic geometry which will revitalize the student's second year in mathematics besides giving him a useful and very powerful tool of fundamental importance in his quantitative study of any branch of life, be it biology, economics, or what not? In algebra we set out to teach methods of solving problems—mostly skill techniques. Let us follow this by a year of showing the student how to recognize a problem, how to set it up for solution, and to recognize a solution.

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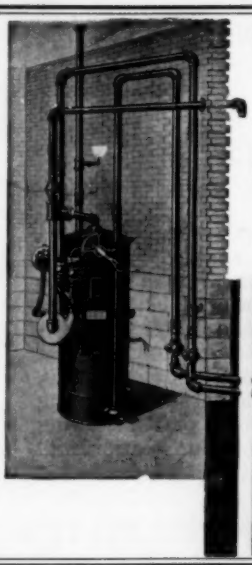

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